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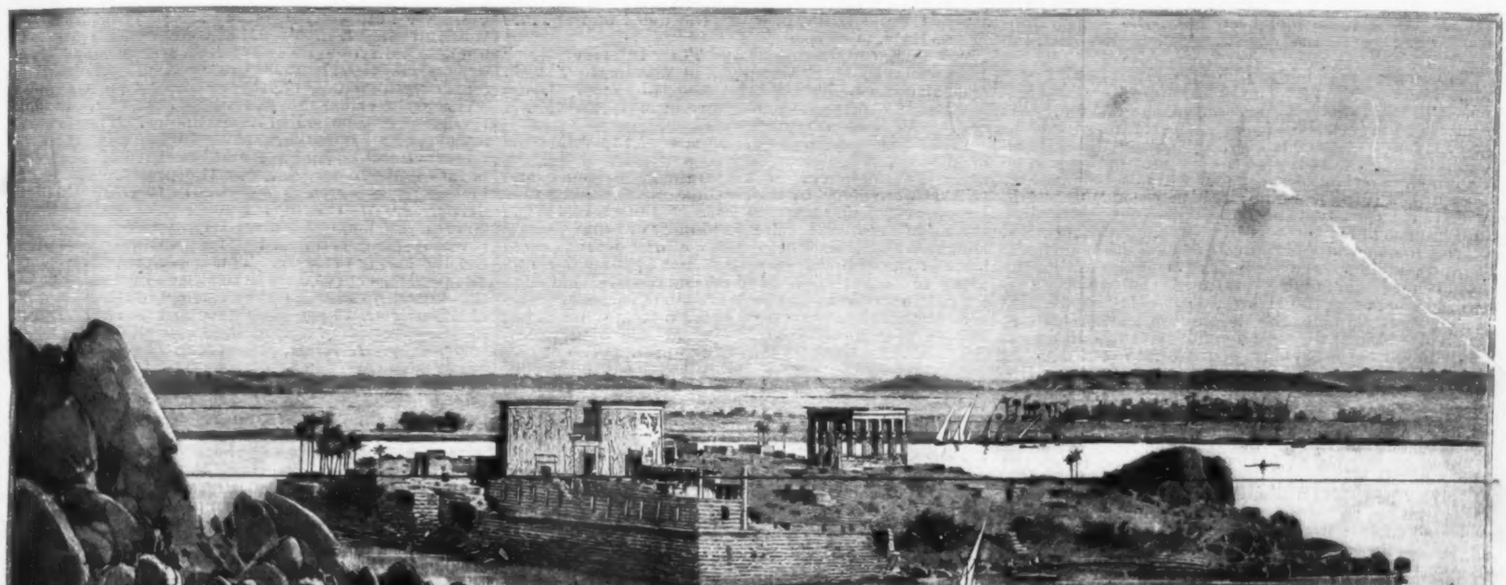
THE ISLAND OF PHILÆ, EGYPT.

DURING the last few years the island of Philæ has occupied a prominent place in the attention of the public on account of a proposal made by an English engineer with reference to the storage of the waters of the Nile in a huge reservoir to be built near the town of Aswân or Syene, in Upper Egypt.

The island is about five miles south of Assam and near the First Cataract. The object of the reservoir was to enable the irrigation department to regulate and increase the supply of the life-giving waters to the cultivated districts in the north of Egypt, and there is no doubt that such a work would have been a great boon to the landed proprietors and farmers of Egypt on both sides of the Nile, from Elephantine in the south to Alexandria in the north. But when the details of the proposal came to be worked out, it was



THE ISLAND OF PHILÆ, SHOWING THE PROPOSED CHANGE IN WATER LEVEL OF THE NILE.

found that it involved the submerging of the island of Philæ for several weeks each year; and every lover of the monuments of Egypt heard with sorrow that the chambers and courts of the temples on it would be covered to the depth of several feet with Nile water. The proposal was criticised keenly by many. That the irrigation engineers were animated by a desire to do their best for the welfare of Egypt was generally admitted, but the dismay caused by the idea of the destruction, whole or partial, of the temples and other Egyptian monuments of Philæ was universal. The farmers' cry for more water has for long been pressing and constant, and it was felt by some that even the interesting monuments of Philæ ought not to stand in the way of the material prosperity of Egypt. Further plans to bring about the desired object were drawn up, and it is understood that a course of action has been decided upon which will both satisfy the irrigation officers and allay the fears of the archæologist.

The accompanying view, for which, and for the particulars herewith, we are indebted to the Illustrated London News, will give an idea of the aspect of the island of Philæ in its normal condition, and when partly submerged. The illustration shows the island as seen from the Libyan or western bank of the Nile, looking south, and the line across the face of the picture shows the extent of probable submersion if the proposed dam is built.

On the eastern side of the island rises the graceful little temple of Isis, commonly known as "Pharaoh's Bed," which was built by Nerva Traianus, and is a very striking object in the landscape. Beyond are the ruins of an arch built in honor of Diocletian's visit to Philæ. In the foreground, which represents the southwestern part of the island, is the famous Colonnade, a work of the Roman period, which is as old as the time of Cæsar Augustus; and a little further inland are the remains of the walls of a hall, part of which dates from the time of Ptolemy V. Beyond these are the pylons and the doorway, which are covered with reliefs and inscriptions, and form most interesting specimens of the later style of Egyptian architecture. The largest scenes on them depict Ptolemy XIII sacrificing to Isis and Osiris, the local gods of Philæ, and the appearance of this king in the presence of the deities Isis, her sister Nephthys, and son Horus. To the left of the left pylon we see the small building which has excited so much interest in every visitor to the chamber in it; here may be seen the relief in which is depicted the body of the dead Osiris carried on the back of a crocodile, and near by is a representation of the Nile god, having on his head a clump of lotus flowers, and pouring out water from two vases which he holds in his hands.

The parts of the monuments to which the archæologist attaches most importance will remain untouched by the water if the dam is built as proposed. Before this happens, however, a most exhaustive and searching examination of the foundations is to be carried out under high authority by skillful experts, and all the inscriptions are to be accurately copied and reproduced for the use of Egyptologists and others. It is idle to suppose that no kings before the Ptolemies ever employed the island of Philæ as a site for buildings and temples, and it is tolerably certain that a careful survey and examination of foundations and ancient remains existing there would produce results which would enable us to reconstruct, at least partly, the ancient history of the island.

Of the history of Philæ in Egyptian times but little is known, and the monuments which now stand there are silent on this point. The island held a prominent place in the religious affections of the people round about, and it was to the extreme south of Egypt as Abydos was to Middle Egypt—most sacred as the burial place of Osiris. At a certain season of the year the mysteries of Isis were performed here in a sort of religious play, wherein all the various labors of Isis in connection with the death and burial and resurrection of Osiris were carefully represented. The scenes explanatory of this play may still be seen on the walls of the chambers at Philæ; and the relief which shows the wheat growing out of the dead Osiris has interested all thoughtful visitors to this shrine. In ancient days devotees flocked thither with offerings, and its importance as a sacred place in Upper Egypt can hardly be overestimated. Its connection with the belief that the source of the Nile lay in the cataract gained it additional honor, and it is possible that certain of the Egyptians thought that the god Khnemu created man here; at any rate, we have depicted on one of the walls a scene in which a god is represented holding in his hand a man which he has just fashioned on a potter's table. In the fifteenth century the Mohammedans had built a mosque with a minaret there.

The picturesque and rare beauty of the place cannot be easily described, and the first view of it which the traveler obtains from the desert is one which will not be forgotten. Many changes have come over the island since the days when Osiris was worshiped there, and when Strabo crossed to it seated in a wicker boat, with his feet in the water at the bottom. But the charm of the spot, with its waving palms, with its marvelous lights and shades, with its manifold associations which belong to a period measured by thousands of years, renders it unique among the many beautiful sites in Egypt.

THE GEOLOGICAL SOCIETY OF AMERICA.

EIGHTH ANNUAL MEETING, AT PHILADELPHIA, DECEMBER 26-28, 1895.

By E. O. HOVEY.

DURING Christmas week Philadelphia was the center of attraction for scientists of all kinds, since the annual meetings of no less than seven associations of specialists in various lines of nature study were held on the three days immediately succeeding the holiday, in commodious rooms kindly placed at their disposal by the University of Pennsylvania. One of the convening bodies was the Geological Society of America, and the sessions of its eighth annual convention were conducted by the retiring president, Professor N. S. Shaler, of Harvard University. The winter meeting is the most valuable of the year, as it is the meeting for work and as it is the most largely attended, since the members who are on the various State and national geological surveys, as well as the college men, are able to be present. About seventy-five members and others attended the sessions this winter, and the meeting was successful in every way, though a smaller number of papers than usual was on the programme. Twenty-seven papers were presented, of which twenty-two were read and discussed more or less fully, the remainder being omitted on account of absence of their authors or for some other reason.

The report of the council shows that the affairs of the society are in good condition. Eighteen new members have been elected, while four deaths have occurred among the old members, six names have been dropped under the rules, and one member has resigned. The next printed roll of membership will probably contain the names of 230 active members. Those who have died during the last year were Professor James D. Dana, Professor Henry B. Nason, Dr. A. E. Foote, and Señor Antonio del Castillo.

Memorials of the deceased members were prepared by Professor Joseph Le Conte, Professor T. C. Chamberlin, Mr. George F. Kunz, and Señor Ezequiel Ordonez. After these had been read, the society proceeded at once to the consideration of the scientific papers.

The presidential address, by Professor Shaler, was an able discussion of "The Relations of Geologic Science to Education." On account of the author's wide and varied experience in matters pertaining to pedagogy as well as to geology, the paper was of special interest, but, owing to the amount of work to be reviewed, mention of the paper will not be made at present. Professor Shaler read a second paper, in which he emphasized the importance of volcanic dust and pumice in marine deposits. Considerations based on the volcanic action in the Java district alone make it probable that the extrusions of rock material in the form of dust and pumice may exceed that which is carried to the sea by the rivers, and possibly equals that which is conveyed to the ocean by all other actions. The volcanoes of Java and immediate vicinity have contributed 150 cubic miles of material to the deposits of the ocean—an amount which it would take the Mississippi River about 3,000 years to equal. Observations along the sea shore of the United States afford evidence that there is a noticeable contribution of pumice to the deposits forming there. The coast deposits of Florida show about 3 per cent. of such material, but the amount diminishes toward the north until it is barely perceptible on the Massachusetts coast. The facts warrant the supposition that the value of these volcanic contributions to sedimentation has not been properly appreciated.

The next paper was by Professor J. F. Kemp, of Columbia College, and was entitled "Illustrations of the Dynamic Metamorphism of Anorthosites and Related Rocks in the Adirondacks." He said, in part: The high central peaks of the Adirondacks and the larger outlying ridges consist of anorthosite, a coarsely crystalline rock, that is nearly pure labradorite feldspar. Although the rock has been described in the earlier geological reports as norite, it is noticeably poor or entirely lacking in ferro-magnesian silicates. In the course of a fairly extensive reconnaissance of the principal portion of the mountains, the author has met but a limited exposure of the anorthosites in their original, uncrushed condition. The best development of such rock is at the Upper Iron Works, at Lake Sanford. Specimens from that locality were shown, and, beginning with these as a starting point, the gradual development of "crushed rims" about the labradorite crystals was illustrated from those which were barely discernible to those which have reduced the original crystals to small nuclei. The extreme is a "pulp anorthosite," with no nuclei. The passage into gneissoid forms, with a rich development of garnets, was shown, together with the final result, which is a finely laminated gneiss. The paper concluded with comments on the geographical distribution of the various types of rock displayed in the specimens.

The list of petrographic papers closed with a short plea for a new term in this branch of geology by Prof. L. V. Pirsson, of Yale University. The petrographer has to deal not with crystals in the usual acceptation of that term, but with crystalline aggregates which have no bounding planes, and in which the inner molecular structure and physical properties are of highest importance. For such a crystalline aggregate the author proposes the term anhedron (plural anhedra) in reference to the absence of bounding planes.

Following these papers the students of physical geography had their say, beginning with Prof. W. M. Davis, of Harvard University, who delivered two rather short but very suggestive papers. The first of these was a note on the outline of Cape Cod, in which the author showed that the ridge of glacial morainic material forming the original backbone of the cape ends at Highland light. Soundings show that this moraine formerly extended eastward several miles to sea. The ocean currents have cut away this former extension and have built up the present cape north and northwest of Highland light, with the aid of the winds which have driven the sand inland.

Prof. Davis' second paper dealt with "Plains of Marine and Subaerial Denudation," and awakened much discussion among the members of the society. The author said, in substance, that Prof. A. C. Ramsay's explanation of plains of abrasion as the product of marine denudation (1847) had found general acceptance, and in England to this day hardly any serious consideration was given to any other explanation of the production of such plains. In 1875 Major J. W. Powell, in connection with the idea of the base level of erosion, contended that plains of abrasion would be formed at the close of a cycle of subaerial denudation (i. e., by the action of winds, rains and rivers). This theory has found wide acceptance in this country but it is less approved abroad. Prof. Davis' paper considered particularly the means by which plains of one origin or the other might be distinguished. When such plains are uplifted and deeply dissected in a second cycle of erosion, the difficulty of determining their origin increases, but the author suggested that plains of subaerial denudation might be recognized, even when uplifted and dissected, by the degree of adjustment of their streams to their structures. Thorough adjustment, however, requires a longer time of stream action than has passed since uplift, and much of the adjustment must be referred to a previous cycle of denudation, which is thus shown to have been a subaerial cycle. Many areas may be unrecognizable definitely, but the Alleghany Mountains show several cycles of denudation which seem certainly to be due to subaerial work rather than to the action of the ocean.

"Cuspate Forelands" was the title of the next paper, which was by F. P. Gulliver, of Harvard University. The action of waves, tides and currents was discussed. Waves attack the whole coast, but erode more rapidly on headlands than at bay heads. The tides are less effective agents of transportation along shore on exposed coasts than currents, but they are the important agents in sounds, channels and inlets. The author divided cusps into three groups. First, current cusps, of which Cape Hatteras is a type, in which the point is formed in the dead water between two eddy currents. Second, tidal cusps. These are formed between eddies of in- and out-flowing tides and project at right angles to the shore. West Point, in Puget Sound, is a type of this form. Third, delta cusps, in which the mouth of a river forms the point of the cusp, on either side of which the shore currents arrange the detritus, of which the delta of the Tiber River, Italy, is a type.

"Drainage Modifications and Their Interpretation." This paper, by M. R. Campbell, of Washington, D. C., opened with a discussion of the subject of stream modification under the influence of slow elevation or depression of the earth's surface.

From this was derived the law of the migration of divides, which controls, to a greater or less extent, the alignment of all drainage systems, and criteria were given by which these modifications may be recognized and the character of the movement of the earth's crust determined. Following this, the author gave, with the aid of maps, a brief description of some of the drainage systems of the Appalachian province, south of the glaciated region, to show that similar modifications of the drainage are of common occurrence, not only in the regions of horizontal rocks but also in the highly complicated Appalachian valley. Some of these changes have taken place in recent geologic time, while others probably date back to the time of the Jura-Trias depression. The main object of the paper, however, was to show that the drainage of the Appalachians constitutes a record of Mesozoic and Cenozoic history, and that this record is to the physiographer of equal importance to that contained in the forms sculptured from the surface of the land.

Mr. N. H. Darton, of Washington, then described some fine examples of stream robbing in the Catskill Mountains, showing by means of manuscript maps on a large scale how the Kaaterskill and the Plaaterskill creeks working back from the east front of the mountains have tapped the north and south branches, forming the head waters of Schoharie Creek, which flows westward and northward into the Mohawk River.

Another paper somewhat related in character to those just reported was by Arthur Keith, of Washington, on some stages of Appalachian erosion. He has studied the stream valleys and divides in working out the problem. These are most uniformly reduced near the large streams and most irregularly near the large divides. The most conspicuous peneplains are at the elevations of 1,500 to 1,600 feet, and at 1,000 to 1,100 feet above tide. There are four such plains in the Tennessee system, and in the whole Appalachian region there are surely seven, indicating as many cycles of erosion. Broad, uniform uplifts, with subordinate local warping, mark the history of the area.

Dr. Robert Bell, of the Canadian Geological Survey, has spent several months of the past year in exploring around Hudson's Bay, and he gave the society some of the most interesting of the results of his labors in a paper detailing the proofs of the rising of the land around that body of water within very recent time. He found well preserved elevated sea margins and grand terraces, especially along the eastern coast. Lines of drift wood exist many feet above the highest known tides, and there is much ocean debris along old shore lines in the woods on the west side. Islands near the shore have become peninsulas within the human period, and salt water marshes have become dry land. The character of lower parts of streams also shows that the sea has retreated. Marsh plants, bushes, poplars, spruces, etc., now occupy land which was under water within the tradition of the inhabitants of the region, and there has been very noticeable shoaling of channels and harbors and extension of islands and shores since the Hudson's Bay Company have had their posts along the coast. The rise seems to have been at the rate of five feet or even more in a century, which is very rapid. Beach dwellings and other shore works of Eskimos in the northern part of the region which are now 70 feet above tide are supposed to be about 1,000 years old.

Prof. C. R. Van Hise's paper on the movements of rocks under deformation was a very valuable contribution to the study of dynamic geology; but it cannot be abstracted here on account of the interdependence of all its parts and its abstruse character. It was a general discussion of the behavior of rocks when subjected to deforming stresses, and continued discussions which the author gave in similar papers at the last summer meeting of the society.

The possible depth of mining and boring is a subject of practical importance, which has lately occupied the attention of Dr. A. C. Lane, of the Michigan State Geological Survey. He has worked out some interesting ideas from data furnished by the extensive mines in the copper region of Upper Michigan. Primarily, of course, the possible depth will be determined by the depth to which it will pay to go, and this again will depend on three factors; namely, the rewards of mining, the resistance to mining and the resources of the miner. Under favorable circumstances the fixed cost of mining, independent of depth, may be set at $1 per ton; hoisting alone, about 8 cents per ton per thousand feet, down to 3 000 feet, and increasing to 25 cents at 10,000 feet. The deeper the mine the less the output, on account of time lost in hoisting. The cost of timbering does not seem to increase with the depth, but it cannot be figured definitely. Barometric pressure and the increase in temperature, due to increase in depth, are very important elements. In the copper country the latter is estimated to be 1° Fah. for every 100 feet, giving 90° at 5,000 feet and 140° at 10,000 feet from the surface. Ease of working in high temperatures depends largely upon the absence of moisture from the air. In the copper mines of Michigan there is so little water below 1,000 feet that pumps are not needed or used in the parts of the mines below that level. The use of compressed air for drills reduces the temperature somewhat. It is not probable, therefore, that mining will be stopped on account of any of these resistances to the work short of 10,000 feet, at any rate, and it may possibly be carried to considerably lower levels. The Tamarack Mine Company is now sinking a shaft which will go 5,000 feet before the ore body will be reached, and this may reach, the 10,000 foot level. When it reaches that profound depth and stops, diamond drill boring may be carried thousands of feet farther and give a geological section such as never before has been deemed obtainable.

In some "Note on Glaciers," Mr. H. F. Reid, of Baltimore, gave the results of much study and many observations made during the past year and before. He says that the glaciers on Mount Rainier have retreated 200 to 300 feet in the last twelve or thirteen years, that those of the Selkirk Mountains, in British Columbia, have noticeably retreated in five years, and that the Muir glacier, in Alaska, also shows the same phenomenon. Above the nevé line, which is the boundary of perpetual snow, is the region of accumulation, and below is that of melting or dissipation. The former may be called the reservoir of the glacier, while the latter may be called its dissipator. The greatest amount of ice flow takes place in the section at the nevé line and both above and below it. The velocity of flow tends to decrease, but the pressure of the following mass increases sufficiently to check this tendency. Above the nevé line the motion of particles is into the mass of the glacier, while below that line the movement is upward and outward, on account of the increasing pressure. This movement of the particles produces curve lines in the glacial mass and bends the layers upward as they emerge in the lower part of the glacier. This phenomenon was clearly shown in a photograph of a Greenland glacier.

Mr. Frank Leverett, of Denmark, Ia., followed this paper with two of much interest to the glacial geologists. The first was on the loess of western Illinois and southeastern Iowa. The northern border of this deposit in this region appears to have been determined by the ice sheet. The loess is apparently an apron of silt spread out to the south by water issuing from the ice sheet. It is loose in texture at the north and becomes finer toward the south, showing a progressive decrease in the strength of depositing currents. The wide extent of the loess over the uplands has led to a consideration of the influence of wind as well as water in its distribution; but it is thought that one form may be distinguished from the other, and that the wind action was subsequent to the deposition by water and of minor importance.

Mr. Leverett's second paper was entitled "The Relation Between Ice Lobes South of the Wisconsin Driftless Area." Instead of a coalescence of ice lobes from the east and the west sides of the Driftless Area in the drift covered district to the south there was an invasion and withdrawal of one lobe (the western) before the other reached its culmination. The eastern lobe encroached upon territory previously glaciated by the western, depositing a distinct sheet of drift and forming at its western limits a well-defined morainic ridge. There appears to have been a period of considerable length between the withdrawal of the western lobe and the culmination of the eastern.

Subsequently, however, there was a readvance of the lobe on the west into northeastern Iowa, and this readvance appears to have been contemporaneous with the nearly complete occupancy of northwestern Illinois by the eastern ice lobe. It seems not improbable that the ice lobes then for a brief period coalesced for a short distance about the south border of the Driftless Area. Evidence of complete coalescence, however, is not decisive so far as yet discovered.

These developments serve to throw light upon the cause for the scarcity of lacustrine deposits in the Driftless Area. They show that there was, at most, but a brief period in which the southward drainage of the Driftless Area was completely obstructed by the ice sheet.

Professor G. F. Wright, of Oberlin, then gave a description of the high level terraces of the middle Ohio River and its tributaries, in which he detailed the results of his personal observations during last summer and autumn between Steubenville and Marietta, on the Ohio River, and between Highbridge and Boonetown, on the Kentucky River.

Four great kame areas of western New York were discussed by Professor H. L. Fairchild, of Rochester. Three of these areas of glacial hills are south of Irondequoit Bay, Lake Ontario, and one south of Sodus Bay. These are remarkable for extent and the quantity of material in them, as well as for location and altitude. One of them has gravel hills four hundred feet high and attains the highest elevation of ground in western New York north of the Devonian plateau.

The papers remaining on the programme dealt with stratigraphic geology. Professor C. H. Hitchcock, of Dartmouth College, has been making occasional studies of the rocks along the upper Connecticut Valley since his official connection with the geological surveys of New Hampshire and Vermont ceased, and he thinks that there are good reasons for revising some of the conclusions of his New Hampshire report. He

has found that there are two bands of argillite, one below and the other above the calciferous mica schist, that the hornblende schist of the neighborhood of Hanover is of igneous origin and is probably a laccolite; and that the protogene gneisses of Hanover and North Lisbon, N. H., are igneous rocks. Furthermore, on account of the determination of these crystalline rocks as of igneous origin, a new arrangement of the fossiliferous rocks of Littleton, N. H., is suggested, to the effect that they are of Upper Silurian and Devonian age.

"The Devonian Formations of the Southern Appalachians" was the title of a paper by Dr. C. W. Hayes, of the United States Geological Survey, in which he embodied some of the results of recent studies in northern Georgia and Alabama and eastern Tennessee, where there is an enormous areal development of strata containing phosphate of lime in commercial quantities. There are two of these phosphate beds, separated by beds of carbonaceous shale of variable thickness up to twelve feet, in which there are occasional phosphatic nodules. The upper phosphate bed is from eight to twenty-four inches thick, while the lower and richer is as much as six feet thick in places. The Devonian age is proved by the presence of certain fish bones. There is much volcanic ash in some of the strata. The phosphate is supposed to have come for the most part, if not entirely, from the shells of a brachiopod, the lingula.

The last two papers on the programme were by N. H. Darton, of the United States Geological Survey, and dealt with the relations to one another of the coastal plain strata of some of the Atlantic States. The formations below the Eocene buhrstone in South Carolina, which were included in the Eocene by Professor Tuomey, have been found to belong to the Potomac formation of the Cretaceous, and are overlain by marine Cretaceous beds, as shown by borings from artesian wells. In the second paper Mr. Darton exhibited a series of sections to show the distribution and variations of the principal coastal plain formations and discussed the new light thrown on them by results of artesian well borings at a distance from their outcrop at the surface.

The social side of the convention was not neglected by the Philadelphians, for there was a handsome reception tendered to all the visiting societies by Dr. Horace Jayne, Thursday evening, and the University of Pennsylvania provided lunch each day in their beautiful library building. The dinner of the Geological Society, Friday night, was attended by about sixty persons, and was enlivened by many impromptu speeches. The new president of the society is Professor Joseph Le Conte, of the University of California, and the next meeting will be a field meeting in connection with the convention of the American Association for the Advancement of Science, next August, in Buffalo.

[L. C. MIALL, IN NATURE.]

THE TRANSFORMATIONS OF INSECTS.*

PRIMITIVE insects, we may suppose, attained the Campodea form in the egg, after which they merely increased in size without important modification of structure. The next step opened the way to extraordinary developments, which were not, however, immediate or necessary consequences. Certain insects acquired wings as adults, while others remained wingless and pursued the old life. The acquisition of wings did not as a matter of course greatly affect the habits of the species.

Some, like the grasshoppers, crickets and cockroaches of to-day, continued to run about on their long legs in all stages, and divided their food with the same kind of jaws as their wingless progenitors. But when full advantage was taken of the new means of locomotion, the life history was profoundly affected, the two extremes, early and late, being acted upon in opposite ways. The imago grew more active and quicker to discover the best sites for egg laying, gradually undertaking the whole function of dispersal of the species. The larva, thus relieved from choice and travel, became slow and clumsy, escaping its enemies by protective resemblance or burrowing. It came to be more and more exclusively occupied with feeding, while the adult, except where the business of egg laying was unusually protracted, fed less and less, sometimes not at all.

The quiescent pupal stage seems to me to have arisen from the contrast between the degenerate, slow, voracious larva and the active, highly organized and sensitive imago. Sagacity and activity gradually declined in the larva, and became exalted in the imago, until the extremes of the life history became so unlike that they could only be reconciled by profound changes, incompatible with locomotion and feeding.

I quite agree with Lubbock's remark, that "the apparent abruptness of the changes which insects undergo arises in a great measure from the hardness of their skin, which admits of no gradual alteration of form, and which is itself necessary in order to afford sufficient support to the muscles." The hardness of the skin in insects and other Arthropods involves periodical moults in order that the body may increase in size. Pupation is an exaggeration of one of these moults, the subsequent escape of the imago is an exaggeration of another. These two moults are the last but one, and the last of all, and the pupal stage, where there is one, intervenes between them.† An ordinary moult gives opportunity for effecting slight changes in the chitinous cuticle. The new skin is not necessarily moulded precisely upon the old one. If increase of size is required, the new skin can be made a little larger, and accommodated within the old one by wrinkling or folding. It is in this way that the wings of an Ephemera, a dragon fly, or a male cockroach gradually attain their full size. If projections of unusual length are to be formed beneath the old skin, they can easily be telescoped into the body; a process which attains a high degree of complexity in some insects.

Many insect transformations, too familiar to be detailed here, illustrate the great facilities afforded by the change of skin for replacement of organs lost by degeneration, or for development of new ones, more elaborate than any possessed by primitive insects.

But for these facilities I imagine that larval degeneration would never have gone so far as it has done in insects; the price to be paid would have been too heavy.

How insects first acquired wings, and from what structure they were derived, is still a profound mystery. A favorite conjecture is that they arose by the modification of tracheal gills. In favor of that supposition is the fact that in some dipterous larvæ (Chironomus, Simulium, Culex, Muscidæ), three pairs of rudiments (imagine folds) form on the dorsal surface of the thoracic segments and as many on the ventral surface. The ventral rudiments ultimately become the legs of the fly. Of the dorsal rudiments the second becomes a wing, the third a rudimentary wing, and the first the respiratory organ of the pupa, which may take the form of a trumpet or a bunch of branching tubes. In the larvæ of the Muscidæ this anterior dorsal appendage is said by Weismann to form much later than the rest, only during the last larval stage, and to be greatly inferior in size. In Chironomus and Simulium it forms at the same time, and is quite similar to them. Where an anterior spiracle exists, as in the Muscidæ, the anterior dorsal appendage forms close behind it, and ultimately replaces it. Now, if it could be clearly shown that all three dorsal appendages form one series, and that one or two are converted into wings, while the foremost becomes a breathing organ, we should at least know that a wing and a breathing organ may have a common origin. So much seems probable, but we must still wait for conclusive facts before we can explain how insects first got their wings.

In many Orthoptera, and other hemimetabolic insects, effective wings are developed without any resting stage. I think that we may safely infer that historically wings were acquired before complete metamorphosis set in, and before insect larvæ underwent degeneration.

Though the fact must, of course, be well known, I do not remember that any zoologist has expressly mentioned that the resting stage of insects is unique among animals. The nearest phenomenon of the same kind is the encystment of certain Protozoa and parasites; but cessation of all the functions of active life, when these have once been assumed, for the purpose of effecting a definite advance in organization, is a thing peculiar to insects. Hence we cannot check our interpretations by examples taken from outside the class. But all insects do not pupate, and we may learn something by studying the hemimetabolic insects in which there is no quiescent pupa.

Nearly all these insects (some few Orthoptera and some Rhynchota are exceptions) ultimately acquire wings, the rudiments of which may be externally visible long before the imago stage is reached. In hemimetabolic insects it is unusual to find any marked change in the food, the mouth parts, the general form of the body, the texture of the skin, the length of the legs, the muscles, or the nervous system. It is often difficult to distinguish a full sized larva from the imago without close examination. In Ephemeridæ, Perlidæ, and Odonata the larva is aquatic and the imago aerial, so that notable changes appear in the mode of respiration, but still the transition is effected without a resting stage.

We have seen that wings may be acquired by insects which pass through no pupa stage. There is, however, hardly a case (the parasitic flea is one) of an insect which pupates without acquiring at least the rudiments of wings in one or other sex. The main purpose of pupation would in general be defeated if the adult were wingless.

Change in the form of the mouth parts, if so considerable as to involve a new method of feeding, e. g., the substitution of sucking for biting, cannot be effected without a quiescent pupa stage. It seems inevitably to involve a rather prolonged interval during which the old mouth parts are not in working order, while the new ones are not yet complete. But though considerable changes in the mouth parts imply a quiescent pupa, they are not the sole reason for pupation. The larva and imago of many Hymenoptera and Coleoptera have similar mouth parts, yet they all pupate. Neither acquisition of wings nor great changes in the mouth parts can be the sole reason for pupation, for pupation is not indispensable to acquisition of wings, and it is not always followed by material changes in the mouth parts.

Lubbock quotes from his earlier memoir on Chloeon (Linn. Trans., vol. xxv, p. 486, 1865) the remark that "the occurrence of metamorphoses arises from the immaturity of the condition in which some animals leave the egg." Insects are specially referred to, for in the memoir quoted we are told that the necessity for change depends on the fact that most insects leave the egg in a very early condition, and that this again is probably owing to the fact that the amount of nourishment in the egg is insufficient to carry the insect to maturity. Brauer adds that the eggs of insects with complete metamorphosis are regularly smaller in proportion to the parent than those with incomplete metamorphosis or none.

I believe that Lubbock's explanation is true of many marine invertebrates, but not of insects. The vast number of eggs laid by a crab or a sea urchin is very likely one cause of the smallness of the eggs and of the unlikeness of the larva to the parent. The transformation which assimilates the larva to the parent is in such cases effected as soon as possible after the migratory larva has settled down and begun to feed. But in the insect there is, as a rule, no important advance in structure during almost the whole of the larval period. If deficiency of nourishment had occasioned a temporary arrest of development, abundance of nourishment would surely have made up the loss sooner. The time of pupation seems to me too distant from the time of hatching, especially as the whole period of active feeding and rapid growth intervenes, to be entirely due to the conditions of nourishment of the larva in the egg. Special facts, of which many could be cited, tell against Lubbock's explanation. The Staphylinidæ commonly lay relatively large eggs, and yet undergo complete metamorphosis. Some insects actually retrograde before hatching out, and lose legs which they had already acquired, a pretty clear proof that want of nourishment was not the cause of what is called their immaturity at birth. The state of the insect at hatching seems to me to depend far more upon the conditions of larval life than upon the supposed privation of nourishment during embryonic development.

It is plain that insects have gained very much by complete metamorphosis. The extraordinary numbers and range of the holometabolic insects settle that fact decisively. If further proof were required, we might point out that the resting stage or quiescent pupa seems never to have been lost in any insect which once possessed it. It is hard to prove a negative, but I cannot call to mind a single clear instance. So powerfully has adaptation acted upon insects that almost every organ and almost every stage is known to disappear at times.

Wings, legs, eyes, mouth organs, head, are known to be deficient in the larva, and a very few adult insects have no functional wings, legs, eyes, or mouth organs. The single order Diptera furnishes us with examples of suppression during the larval stage of all these organs. The egg, the larva, the winged imago may disappear as independent stages in the pupiparous Diptera. But the quiescent pupa remains in every case where it can be shown to have once existed. At most the pupa (in holometabolic orders) becomes in some degree capable of locomotion; it never feeds.

We cannot reckon among the advantages secured by complete metamorphosis the acquisition of wings, for many insects which acquire wings have passed through no resting stage. Among these hemimetabolic insects are the dragonflies, which take their prey on the wing, but in general the hemimetabolic insects gain nothing by flight, except facilities for dispersal and egg laying. The female ant, and apparently the Ornithobia, lay aside their wings as soon as the eggs are fertilized. In adult hemimetabolic insects the mouth parts are either like those of the larva, or not functional at all; the form of the body, the texture of the cuticle, the organs of sense, and the legs are in general those of the larva, so that we might consider the imago as merely a winged and sexually mature larva.

But the imago of the holometabolic insect is always more than a winged and sexually mature larva. It differs in the form of the body, in the internal anatomy, in the organs of special sense, and usually in the structure of the mouth parts. Perhaps the smallest advance upon the larva is seen in the imago of the Adephagous Coleoptera, but even here, though the mouth parts are generally similar and the wings often rudimentary, the difference between the adult and the larva is much greater than in a locust, cricket, or cockroach. Some anatomical comparisons which I have made between the larva and imago of the Carabidæ point to great changes in the muscular system as sufficient to explain the retention of the resting stage even in the absence of other motives. The changes in the muscular system are rendered necessary by extensive changes in the shape of almost every segment and every appendage. But the reason of these changes of shape is sometimes hard to discover.

The greatest advantage won by holometabolic insects is access to the pollen and honey of flowers. Both flowers and insects benefit by mutual help, and have become specially modified to make the most of it. Perhaps no ametabolic insect regularly visits flowers. Some small Hemiptera, which are hemimetabolic, do so, but I believe that their visits have not called forth any special adaptation on either side. The Coleoptera, though holometabolic, have biting jaws, and this may be the reason why so few of them regularly haunt flowers. Hermann Müller tells us that some tropical beetles have the maxillæ specially modified for honey sucking.

Three large orders of highly organized insects contain a greater or less number of honey sucking species. These are the Diptera, the Hymenoptera, and the Lepidoptera. The honey sucking Diptera are comparatively few, but they are of importance to flowers, many of which depend upon their visits for the fertilization of their ovules. The honey sucking Hymenoptera are the bees. Of all insects these make the greatest use of honey and pollen, feeding on them throughout life; they exhibit a more elaborate collecting apparatus, and have acted with more effect upon the organization of flowers than any other insects. In Lepidoptera honey sucking becomes more frequent than in any other order. Every moth and butterfly that feeds at all sucks honey, to pass over such unimportant exceptions as the fruit eating moths with perforating proboscis.

It is a striking proof of the importance of insects in nature that they should have been able to call into existence a profusion of beautiful flowers. All the flowers of the garden and conservatory, all the wild flowers which delight us by their perfume, color or form, are in a sense the work of insects. What they found ready to hand was a multitude of green or sober tinted flowers of small size, without honey or scent; the visits of insects have done all the rest. Flowers have done almost as much for insects as insects have done for flowers. Flowers are to innumerable tribes of insects all that domestic animals and cultivated plants are to mankind. Honey, which may be considered a joint product of the flower and the insect, owes its great importance to three properties. It is fluid, it is highly nutritious, and it can be stored without undergoing putrefaction. Its fluidity and concentration render it particularly suitable as a food for those winged insects which lay their eggs singly or a few together on scattered plants of one kind, and which must, therefore, spend much time in egg laying, as well as to those which spend much time in excavation or building. Upon the fact that honey can be stored for many months depends the whole domestic economy of many species of bees and ants. The chemical possibility of the conversion of honey into wax was a discovery made by bees to the great advantage of their architecture. Not only have special instincts been founded upon the properties of honey, but its pursuit has led to increased swiftness on the wing, keener perception of color and distance, as well as to obvious modifications of mouth parts and stomach.

Like other facilities which encourage activity and intelligence in the adult, honey sucking tends to arrest the development of the larva. The parent undertakes all responsibility and labor, and leaves the young with nothing to do but to feed and grow.

Honey sucking is associated, but not rigidly or indis-

* Continued from SUPPLEMENT, No. 1045, page 16708.

† It has come to pass, by some process which I cannot trace, that in Ephemeridæ, where there is no pupal stage, the fly quits the water at the last moult but one, and immediately afterward casts another very thin skin.

pensably, with the highest faculties ever attained by insects. It marks, perhaps, the highest phase in their evolution. No insect can get so high without passing through a quiescent pupal stage, for without metamorphosis it cannot acquire organs of sufficient delicacy. Those which attain to honey sucking have within their reach all the accomplishments and all the civilization of which any insect is capable.

To any one who considers the great importance of honey in the life of the higher insects, it is a surprise that ants should have climbed so high without honey sucking. They have biting jaws, and the workers have no wings. Hence they are useless for the fertilization of flowers, and many flowers have developed elaborate obstacles for the express purpose of excluding ants. Ants, however, do supply themselves with honey in spite of all obstacles. They will get it from Aphides, if no better way can be found. Some ants have learned to store honey in subterranean receptacles, the most singular of which are the enormously dilated crops of certain individuals of the community, which sacrifice themselves for the good of the rest, and are converted into enormous, globular honey pots. The Myrmecocystus, of Mexico, and the Camponotus, of Australia, furnish us with examples.*

It would seem as if ants had sacrificed their wings for the sake of carrying on their subterranean life with greater ease. They have paid a heavy price for this advantage, for loss of wings in the end involved exclusion from flowers. The bees have managed to keep their wings, and yet to build elaborate structures for the family.

Beginning with the Campodea form, insects have ascended through through several degrees of specialization, acquiring first wings, then complete metamorphosis, and lastly attaining to honey sucking. They have also descended through equally marked stages, losing length of limb first, then losing their limbs altogether, and in extreme cases losing their heads and jaws almost completely. The highest perfection of the insect type is always found in the adult, the lowest degeneration in the larva. To the intervention of the resting stage is due a singular relation between the two processes of evolution and degeneration, which is, as far as I know, peculiar to insects. In insects, as a general rule, the higher the organization of the adult, the lower the degeneration of the larva. The complete metamorphosis of the Coleoptera, Lepidoptera, Hymenoptera, and Diptera, has rendered it possible for their larvæ to degenerate, and yet recover in a later stage all that has been lost. The grubs of the weevil and the bee would not have lost their legs if the parent had been unable to provide them with a store of food sufficient for the whole larval period, which could be devoured without leaving the place of hatching. The maggot would not have lost head and jaws if the fly had been unable to lay its eggs in an abundant supply of highly nutritive food.

The illustrative table will render it easier to realize that in insects, as a general rule, special development upward involves special development downward in an earlier stage, and also that only a very moderate difference between the extreme forms of the larva and the adult can arise without a resting stage. Abundance of food, and a life without exertion, often render the larval skin soft and extensible. Since in

EVOLUTION AND DEGENERATION OF INSECTS.

	Thysanura	Orthoptera	Coleoptera (Adephaga)	" (Lamellicornia)	" (Weevils)	Hymenoptera (Saw flies)	" (Bees)	Lepidoptera	Diptera (Nemocera)	" (Muscidæ)	" (Syrphidæ)
Honey sucking							•	•			•
Complete metamorphosis			•	•	•	•			•	•	
Wings											
Campodea	•	•	•								
Legs reduced				•		•		•	•		
No legs					•		•				
Head reduced										•	•

insects the chitinous cuticle furnishes a chief part of all the organs of locomotion, of prehension, and of special sense, a soft, extensible skin involves complete degeneration. This may last throughout the whole larval period, during which the external conditions are usually the same. Then comes the sudden change to a stage in which a maximum of activity and intelligence is called for.

It will be evident to those who have previously studied the subject that Fritz Müller has been my chief guide in this discussion. We owe much both to Brauer and to Lubbock, but I think that we owe to Müller, and indirectly to his master, Charles Darwin, the most considerable advance in the philosophy of transformation that has been made for two centuries.

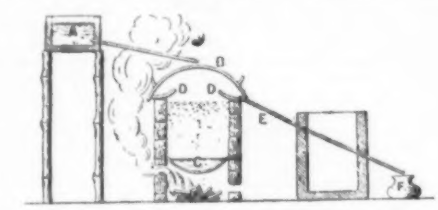
THE ANISE SEED TREE IN TONKIN.

INDIGENOUS to northwestern China, but spread abroad to Tonkin, India, Japan, Java and the Philippines, the star anise seed tree is one of the genera of the order Magnoliaceæ, and even constitutes a group bearing the name of Illicieæ. The species that we shall occupy ourselves with at present is the Illicium anisatum. This tree ought to interest all those who appreciate the excellent anisette of Bordeaux and all drinkers of absinthe. In fact, as odd as the thing may appear, anisette, despite its name, owes its odor and taste to the fruit of the tree under consideration, and absinthe finds its active principle in the same fruit.

The star anise is a tree from 10 to 15 feet in height, with alternate, lanceolate, persistent leaves without stipules, very aromatic and resembling those of the laurels. The flowers, which are of a yellowish color, grow from the axil of the upper leaves. They are regular and expand in May.

But what interests us is the fruit, since it is this that furnishes the valuable aroma used for making anisette, absinthe, and even a few other liqueurs. The fruit is in general composed of from 8 to 12 ligneous follicles, stellately arranged, flattened laterally and ending in a pointed beak. After the fruit has reached maturity, each of the follicles opens and discloses a single seed. This seed is the star anise of commerce. The wood itself of the tree, which is much used in China in marquetry, exhales a strong odor of anise; but the odor is much more pronounced in the seeds that come from the dehiscent follicles. It is on account of this similarity in order to the true anise belonging to the order Umbelliferæ, and on this account alone, that the tree bears in commerce the name of "star anise."

The star anise is in great favor in China, where the Celestials chew it after meals, in order to perfume their breath. They think that the seeds taken in infusion restore lost vigor. As they are tonic and stimulant, they must facilitate digestion. They furnish the arrack of India and serve as a basis for the ratafia



CHINESE APPARATUS FOR THE DISTILLATION OF OIL OF STAR ANISE.

of Bologna. But, as we have said, the principal use of the star anise and the essential oil extracted from it is for the manufacture of anisette and absinthe. Should we go to Dong-Dang, upon the frontier of Tonkin and China, we would there be able to study the exploitation of the star anise. Upon traversing this country we see the valleys cultivated as rice fields, but the hills are covered with star anise trees. It appears that the latter often grow spontaneously in the virgin forests, but here upon these slopes we find them cultivated especially by the Thos.

The fruit is ripe in June or July, but, as a general thing, it is gathered while it is still rather green, the cultivator being obliged to harvest his crop prematurely, lest perhaps it may be taken away from him. This evidently diminishes the rendering of the seed in essential oil. It must be noted, in fact, and this is a curious thing, that it is not the seeds that are exported, but the oil extracted therefrom upon the very spot where they are produced and by other hands than those of the cultivator. The Thos, who devote themselves to the culture of this tree, sell all the fruit to the Chinese, who have made a monopoly of the manufacture of the oil.

What is odd is that the small works that they set up are all merely temporary. They come only for the season and establish themselves in the summer in the villages in which the star anise is cultivated. All these Chinese are natives of Kouang-Li, and they reach the province of Lang-Sou at the epoch of the manufacture. Moreover, they bring with them each season all the material of their distillery. It is just to say, however, that the inventory of this is easily made. It consists simply of a caldron, which constitutes the essential part of the distillation. The other parts of the still can be found in situ, they being formed principally of bamboo. The accompanying figure almost explains itself. At A is a receptacle mounted upon bamboo legs and containing water which flows out through a bamboo tube upon the cover, B, of the caldron, C, placed over a rude furnace. The vapor containing the oil of star anise rises to the top and beneath the cover of the caldron, and, in the presence of the latter, cooled by the water coming from the reservoir, A, condenses and falls in part upon the incurved edges, D and D', and then flows through the inclined tube, E, and passes through another receptacle filled with water, whereby it is cooled. This tube performs the role of the worm of improved stills. The oil, finally, enters the vessel, F, which collects the products of the operation.

The manufactured essential oil is shipped to Canton by way of That-Ke. Very naturally these processes are too primitive and involve a great loss of crude material. Nevertheless, the production of the oil was formerly quite large, and there were from 150 to 200 distilleries in operation at Dong-Dang and That-Ke; but since the war the trade has greatly fallen off, to the great detriment of this entire region. The market for the oil, which has been maintained from time immemorial at Hanoi, has been transferred to Hong-Kong.

CORDYLINE BANKSII ON STEWART ISLAND.

THIS fine "palm lily" is one of the most beautiful and interesting plants in the New Zealand flora. Although occasionally cultivated in the southern portions of the British Isles, it is not so well known as it ought to be, from the beauty of its inflorescence, and the picturesque effect of its long drooping leaves. The drawing presented herewith is from a photograph taken by Dr. J. R. Riley, of Winton, and represents a specimen of the Banks' palm lily, planted as a seedling on the island of Ulva, Paterson's Inlet, Stewart Island, by the late Mr. Charles Traill, in 1888, and flowering for the first time in 1894. Its present height from the base of the stem to the apex of the panicle is about 11 ft.; the leaves are between 5 and 6 ft. long, and about 3 in. broad in the middle, being narrowed into a rounded leaf stalk, which becomes slightly expanded at the base; a longitudinal red band runs down the middle of most of the leaves, and increases the beauty of the plant. The huge open panicle, which in old plants is drooping, and often from 7 to 8 ft. in length, is characterized by the long, slender, and rather distant branches usually forming a right angle with the rachis, and is at once singular and beautiful, resembling a large specimen of ramifying white coral. The

CORDYLINE BANKSII ON STEWART ISLAND.

* Lubbock, "Ants, Bees, and Wasps," p. 19.

common palm lily. C. australis, differing in its short stiff leaves, and smaller more compact panicles, although scarcely less beautiful than C. Banksii, is certainly less graceful, and presents a strong contrast with that species, while it attains a much larger size, specimens 60 ft. high, with a trunk 6 ft. in diameter, being occasionally observed; C. Banksii rarely exceeds 10 ft. in height. C. australis is distributed throughout the colony from the North Cape to Stewart Island, but C. Banksii is only found in the North Island, and in the northern part of the South Island as far south as Westland. Stewart Island is separated from the South Island of New Zealand by Foveaux Strait, and has a very interesting flora, containing many endemic plants of great beauty; its climate is mild and remarkably equable. Although the atmosphere is almost constantly saturated with moisture, the actual rainfall is scarcely larger than that of Cook Strait, say about 42 in. per annum.

An account of its flowering plants and ferns was published in the Transactions of the New Zealand Institute, xii (1888), pp. 213, 234. Stewart Island is of especial interest as forming the extreme southern limit of arborescent ferns, which extend to the South Cape, lat. 47° 25', instead of to 45° 50', as usually stated in our textbooks.

The tree fern on the right hand side of the drawing is Dicksonia squarrosa; the trees shown at the back are the Kamahi, Weinmannia racemosa.—T. Kirk, Colonial Museum, Wellington.—The Gardeners' Chronicle.

LUDDEMANIA TRILOBA (ROLFE, N. SP.)

THIS beautiful species is one of the recent discoveries of Consul F. C. Lehmann in the Andes of Colombia, and it has been flowered and twice exhibited before the orchid committee of the Royal Horticultural Society by Sir Trevor Lawrence, Bart. On the last occasion (November 16) the fine plant from which our illustration was taken was shown, and was unanimously awarded a first class certificate. Luddemania triloba is a plant of considerable floral beauty, as well as one of remarkable botanical interest. The plant had a pendulous inflorescence over two feet in length, and bearing thirty-three wax-like flowers of bright orange color, the sepals being tinged with copper-brown, and the base of the lip, which is distinctly three lobed, having a dark purple blotch. By reference to our illustration, it will be seen that the plant requires to be grown in a basket, if for no other reason than to allow of the proper display of its inflorescence. The best situation for it is the intermediate house, and in its culture it has the same requirements as the Acinetas. —The Gardeners' Chronicle.

LUDDEMANIA TRILOBA—FLOWERS OF NATURAL SIZE, ORANGE COLORED.

DURING the severe frost of last winter a curious phenomenon was observed on the frozen surface of Lake Neuchatel, in Switzerland. Cones of ice over six feet in height were formed, each having a crater large enough to hold a man. Professor Dufour, of Morges, who has given a description of the cones, does not account for their formation.

STAR HUNTING BY CAMERA.

PHOTOGRAPHIC WORK OF HARVARD'S ASTRONOMICAL STATIONS.

PARTICULAR attention has again been drawn to the work of the Harvard Astronomical Observatory, both by the discovery of Nova Carinæ, a new star in the constellation of Carina, and by the shipment of the magnificent Bruce photographic telescope to the astronomical station at Arequipa. During the last 2,000 years, from the beginning of the record by the famous astronomer Hipparchus, the discoverer of the first so called new star, B. C. 134, down to the present day, only fifteen of this description have been noted, an average of less than one in a century. It is a triumph, therefore, for Harvard Observatory to have made the latest addition to this notable list, and, more even than this, to have won this credit twice in succession. Before the coming into view of Nova Carinæ, the last in line was Nova Normæ, also a discovery of the Harvard Observatory, made exactly two years earlier.

These stars, technically styled new, are not permanent additions to the heavenly host. They come into being or into sight only to grow with an intensifying radiance for a few weeks or months and then to fade away by dissolution into gaseous nebulæ. The special interest attaching to these transitory beacons of the sky is in the material which they afford to students for instructive analysis and comparison and the light which they cast on the formation of the universe and its laws.

For the extension of this scientific investigation the Harvard Observatory is to-day pre-eminently fitted. It is by no particular or unearned favor of fortune that this observatory is to-day in the forefront of discovery, but simply because of its unequaled completeness of equipment in astronomical stations, appliances, and observers. Its stations at Cambridge, Mass., and at Arequipa, in Peru, on the slope of the Andes, afford a complete field of view of the heavens surrounding both the Northern and Southern hemispheres. This comprehensive range of survey is necessarily beyond the reach of any single station, no matter how advantageously situated or superbly equipped for observation. It has also at Arequipa the largest refracting telescope in use on the Southern hemisphere, at a point where the steadiness and clearness of the atmosphere are exceptionally favorable for astronomical work. This instrument, a thirteen inch Boyden telescope, is not of large size compared with the thirty-six inch Lick refractor or with many others north of the equator, but its observations are of great comparative value in view of the fact that there are so few telescopes of even moderate power in the stations south of the equator.

The Harvard Observatory has the distinguished honor of having been the first to undertake stellar photography and of having carried the undertaking to proportions beyond any suggestion of rivalry. The first photographic image of a star was taken at the Cambridge Observatory by Prof. G. P. Bond and J. A. Whipple on July 17, 1850. A daguerreotype plate was used and only the brightest stars left a permanent image. A few years later the work was resumed with the use of the collodion process and glass plates, and many excellent photographs were thus obtained. In 1872 Dr. Henry Draper was first to succeed in making a photograph showing the lines in the spectrum of a star, and with the aid of more sensitive plates and other improved appliances the observatory during the last ten years has made great progress in the application of the art and in its collection of plates.

In photographing the stars a set of lenses prepared for the purpose takes the place of the object glass in the telescope, and by the attachment of a prism to the lenses photographs of the stellar spectra are obtained. It is through the photographic telescopes that the recent discoveries of new stars have been made, for an examination of the exposed plates showed a marked difference in the spectra which is apparent even to an untrained eye. With the use of the most sensitive plates the faintest stars visible to the eye through the telescope have been photographed, and, in the photographs of nebulæ and the most distant stars, the astonishing result has been attained of the reproduction of stars too faint to be seen by the most powerful telescopes. The area of sky covered by the plate used by the Harvard Observatory is 100 square degrees, and as the total area of the sky is about 40,000 square degrees, 400 plates are sufficient to map the entire sky. Complete photographs of the heavens have been repeatedly made by the observatory, and individual stars and clusters and regions of the sky of special interest have been covered by elaborate series of plates of the utmost value to the student for the investigation of stellar problems. The collection of plates now stored at Cambridge in a building constructed especially for the purpose exceeds 50,000 in number, and the addition from year to year of about 7,000 plates is now going on.

"What has been done recently for the extension of the work of the Harvard Observatory?" Prof. Edward C. Pickering, director of the observatory, was asked recently at the station in Cambridge.

"A twenty-four inch photographic telescope has been provided, and is now on the way to the station at Arequipa," he said. "This powerful telescope, when erected in a position so favorable for observation and photographic work, will be of much service in the determination of points now doubtful and generally in the extension of our knowledge of the stars visible from the Southern hemisphere. We have completed also and are now maintaining a series of stations for meteorological observation extending from Mellendo, at a point about 100 feet above sea level, to El Misti, on the summit of a mountain 19,200 feet high. The intervening stations are Santa Ana, 3,000 feet above sea level; La Joya, 4,150 feet; Arequipa, 8,000 feet; Cuzco, 11,000 feet; Alto de los Huesos, 13,390 feet; and Mont Blanc station on El Misti, 15,600 feet.

"At the more elevated stations it is impracticable to keep observers continuously during the winter season, but this drawback has been obviated in part by the use of the meteorograph, an instrument operated by clockwork and recording automatically wind direction and velocity, pressure, temperature, and humidity. The meteorograph at the Mont Blanc station makes each record on a separate roll of paper, and the five rolls are operated by the same clock, which will run

eight months without rewinding. The meteorograph on the summit of El Misti is in service at the highest elevation of any winter station in the world. This instrument was designed and made especially for this station, and it will be very gratifying to us if we succeed in making a continuous record at this and other stations in face of the apparent difficulties."

"What are the most urgent needs of astronomical research to-day?"

"An increase in the number of observing stations south of the equator," he replied, "and an increase in the power of the telescopes in these southern stations. It is a singular fact, and one not very creditable to the discretion of our astronomical endowments, that the northern hemisphere is so overloaded proportionally with observatories. Of the eighty telescopes in use to-day, with object glasses of twelve inches diameter or more, seventy-six are in stations north of the equator and only four, or one-twentieth of the whole number, in stations in the Southern hemisphere. Of this scanty proportion, too, not one has an object glass exceeding thirteen inches in diameter, or, in other words, there is no refracting telescope south of the equator to-day of one-half the size of our largest instruments in North American or European stations. When we consider the comparative novelty and possibilities of the southern field of observation, it is really vexing to see endowment after endowment going into the erection of new northern observatories or additional telescopes when the Southern hemisphere is so destitute.

"There is a misplaced local pride, too, on the part of well-meaning contributors which insists blindly on the erection of an observatory as if it were a local monument or attraction. The atmosphere of any large city is inevitably clouded and unsatisfactory for an astronomical station, and the essential freedom from jarring cannot possibly be secured within city limits. Moreover, the introduction of electric lights, brilliant and desirable as they are for city service, is found to interfere seriously with the observation of faint objects, such as comets, nebulæ, and zodiacal phenomena. In truth, the ideal place for the location of an observatory is in the heart of a great desert or on an isolated mountain peak, but these situations are doubtless less desirable than city streets for advertising purposes, if observatories are to be erected chiefly as memorial tablets or for the attraction of sightseers."

"What are the probabilities or possibilities of marked advances in our scientific knowledge of the stars and planets?"

"In photography as applied to astronomy the principal advance to be looked for is in the increase of sensitiveness of plates, but it is unfortunately true that certain difficulties in the way of their use will inevitably increase with the sensitiveness. The fogging of the plates on moonlight nights is already so great that long exposures cannot be made with telescopes of large angular aperture, and any marked increase of sensitiveness will make it impossible to work to advantage in the vicinity of a large city, on account of the illumination of the atmosphere by artificial light. It will then be necessary to take the photographs in places far from centers of population, and preferably at great elevations, where the reflecting atmosphere is diminished in amount.

"As to the possible enlargement by this or other means of the number of stars known to us, no approximate limit can be fixed. It has been estimated that as many as 20,000,000 distinct stars will appear upon the planisphere of the visible heavens when completed by the photographic reproduction of all stars down to the fourteenth magnitude. In the investigation of the planets, the application of photography is of comparatively slight service. This is particularly illustrated in the contrasted views of Mars obtained from a photographic plate and by the drawings made from the telescopic observations of this planet. Of the invisible and immeasurable regions, beyond the furthest reach of any instrument known to us to-day, we can only conjecture by inferences from the heavens within our range of view. It is safe to say, however, that there is no evidence that we are approaching a limit in our knowledge of the extent of the universe." —N. Y. Sun.

THE CLIMATE OF PHŒNIX AND THE SALT RIVER REGION OF ARIZONA.

By W. LAWRENCE WOODRUFF, M.D., Phœnix, Arizona.

THE inquiries about Phœnix and the Salt River Valley as a health resort are becoming so numerous that I take it the profession at large will welcome facts concerning this valley, and facts only I will endeavor to state in this article. My aim is to cover the ground fully with the most reliable data attainable.

Phœnix and the Salt River Valley are situated in latitude 33° north in the southwest quarter of Arizona. The valley is from five to seventy-five miles wide, and about two hundred miles long, and throughout its entire length and breadth has a climate claimed to be the best in the world. To rightly appreciate the claims of this valley as a health resort, we must for a moment look at the physical geography of this region. There are high mountain ranges to the north and east, also the Sierra Nevada and cost ranges to the west, with a short spur of low mountains to the south. The high mountain ranges protect this section from all cold winds, and to this protection from cold nature has added yet another feature, which is mainly the cause of the phenomenal climatic conditions found in this region, namely, proximity to the Gulf of California. The Salt River Valley, with the Gila Valley, its extension to the southwest, is an open valley with continuous mountain chains of more or less altitude on either side, and practically maintains these characteristics clear to the head of the gulf. The Gulf of California, with the coast range on its west to protect it from cold northwest winds, and a lower mountain range east of it, is so situated that it catches and retains the warm winds and ocean currents from the Indian Ocean and the equatorial Pacific, and passes them up to the head of the gulf, and, consequently, is largely responsible for the warm, mild winters. It will be seen by the above how nature has provided a channel whereby in this southwest corner of the United States she has reproduced a climate tropical in all its essential parts, with none of the drawbacks of the tropics, namely, excessive humidity and malaria. Here, right in our midst, nature has given a climate as mild and balmy as that of the tropical Pacific islands, and with the same even temperature, and at the same time at an altitude of only eleven hundred feet, a dryness of atmosphere equaled by few localities and excelled by none other in the civilized world. It will now be understood how a climate that seldom gives a temperature at the freezing point, with rarely a cloudy day (there is less than one in ten during the winter, and for weeks at a time during the summer there is not a cloud in the sky), is possible at this latitude. Here is found every element that goes to make up a perfect climate. The best proof on this point is the exceptionally low death rate, which is 8 11-100 per 1,000 inhabitants. This sun-kissed valley has but two seasons—the winter season, which is a happy blending of fall into spring, and the summer, which commences about May 1 and continues until about October 1. The summer days are bright, clear, and hot, with a maximum daily temperature ranging from 96° to 112°. It is as rare for the mercury to go above this in summer as it is rare for it to go below the freezing point in winter. There is usually some little rain in the latter part of July or during August, usually in showers, possibly averaging an inch of rainfall during the summer season. To rightly appreciate the effects of the summer heat, one must recognize the difference between a wet and a dry bulb thermometer. The difference is usually from 20° to 30°. Here the reading of the wet bulb gives our actual sensible heat, while in more humid countries the reading of the dry bulb is so nearly like that of the wet bulb that the difference is rarely perceptible. The average humidity is only about thirty per cent. for the year, and there are weeks at a time during the summer when it will run far below this point. This is the reason, coupled with the fact that there is always a gentle breeze stirring, why our summers are not only endurable, but, in fact, do not cause as much discomfort or prostration as is experienced in other parts of the country. The summer months are the healthiest of the year. During these months the death rate is only one-third of one per cent. Bowel troubles and fevers are almost unknown during the heated term, there being less than two deaths per month from all forms of bowel troubles among infants in a population of 14,000. Is there another place in the world that can make such a showing? During these months perspiration is very copious, and, owing to the very dry air, evaporation is instantaneous and a material aid to comfort. With this statement the fact will be readily understood that rheumatism, kidney diseases and diseases of the respiratory tract make their greatest improvement during this half of the year. This is especially so with persons suffering from insomnia and nervous prostration. Sunstroke is unknown, and it is as safe for people to come here during the heated term as at any other time of the year.

Now, as to the winter months. The visitor will find the days balmy, dreamy, restful; the air pure, dry, bracing; the nights cool and delightful. Save during the rainy season, it is perfectly safe and comfortable to be out of doors day and night. The rainy season usually lasts a week or so, and the rainfall is not heavy. The annual precipitation is something less than seven inches. The following table shows the maximum temperature for a period from December 31, 1894, to January 9, 1895, inclusive, at several places. An examination of this table will show that Phœnix has the most even temperature of all the places named, with but two exceptions, one being Cairo, Egypt, whose highest temperature is 65° —but 1° above our lowest, 64°—and Malta, with 59° as the highest point reached, being 5° below our lowest point. These two places—as, indeed, do all the rest named—have a damp, moist atmosphere, which greatly increases the perceptible difference in the range of temperature.

This valley has everything that goes to make up a perfect winter home. It has the minimum of rainfall —7 in. per annum; second, the minimum of atmospheric moisture—30 per cent. humidity; third, it has the minimum of air movement (its annual average is less than two and one-half miles per hour, and is generally from the southwest; fourth, the minimum of death rate, being but 8 11-100 per 1,000 inhabitants; fifth, the minimum of malaria, there being none;

Date.	Phœnix, Ariz.	Los Angeles, Cal.	Jacksonville, Fla.	Tampa, Fla.	St. Augustine, Fla.	Hot Springs, Ark.	Nice, France.	Malta.	Cairo, Egypt.	St. Moritz, Switzerland.	Rome, Italy.
December 31, 1894....	74	61	44	60	28	30	51	59	65	50	44
January 1, 1895......	74	63	49	60	28	49	53	59	65	50	39
" 2, "	68	61	60	58	32	49	53	59	65	48	35
" 3, "	72	61	60	68	60	50	46	52	65	57	35
" 4, "	70	55	61	52	50	50	46	57	63	52	35
" 5, "	68	55	54	62	52	49	44	54	64	52	28
" 6, "	70	53	62	62	52	49	46	54	63	57	..
" 7, "	68	57	75	62	52	49	42	54	65	50	41
" 8, "	65	62	74	62	68	48	41	59	64	42	39
" 9, "	64	68	68	78	68	49	50	54	64	42	39
Range of temperature for the ten days.....	10	15	31	26	40	11	12	7	2	15	16

sixth, low altitude—1,100 feet above the sea level; seventh, the maximum sunshine—an average of nine days out of ten of bright sunshine, when out-of-door life is enjoyable and healthful. We have here within easy reach and within the bounds of our own country, all the merits ascribed to Italy or Egypt, with none of their drawbacks. We have all that Florida enjoys, with none of her moist, sticky atmosphere and none of her malaria. We have the same balmy air and even temperature of California, without her fogs, dampness or malaria. We have the same dry, bracing air that has Colorado, without her blizzards and high altitudes. We have all, and infinitely more, of all the good things claimed for these localities, without their unfavorable conditions. There may be a few localities where the actual difference in temperature between day and night is less than in the Salt River Valley, but these places have much greater humidity. As in summer, so here in winter, with our very dry air, the perceptible difference between day and night temperatures, and the actual discomfort experienced thereby, is much less than is the case in localities with more moisture in the air. Situated in the midst of this valley, about 150 miles from the head of the Gulf of California, 1,100 ft. above sea level, lies Phœnix, the capital of Arizona and the metropolis of the Salt River Valley. It is the healthiest city in the known world, and is surrounded by a prosperous and constantly growing farming community. It has all the modern improvements and the snap and vim of the young metropolis. Her citizens are quiet, peaceable, and law-abiding, and ready to receive with true hospitality those who seek her perpetual sunshine. The town is making a phenomenal growth, in spite of the hard times, and will soon have the best accommodations for the health seeker, who will find the pure, dry, warm, health-giving air free for all.

The following comparative mortality table shows the yearly deaths in 1,000 inhabitants in the cities named. It will be noticed that Phœnix stands at the head of the list. Phœnix, Ariz., 8·11; Los Angeles, Cal., 14·40; Long Branch, N. J., 9·88; Atlantic City, N. J., 18·38; St. Paul, Minn., 9·60; Minneapolis, Minn., 9·40; San Bernardino, Cal., 11·30.

Now, as to diseased conditions: Asthmatics usually receive prompt relief and a permanent cure, the dry, warm air and low altitude agreeing with them perfectly. If there is a recurrence, it is during the rainy season, and is usually but slight, to disappear again as soon as the usually dry atmospheric conditions prevail. This is equally so of aphonia, bronchitis and laryngitis; and, in fact, of all diseases of the respiratory organs. Tuberculosis, by the dry, hot air of summer, is checked in its development; and, if the patient is not in the last stages, a continuous residence under these favorable conditions will greatly prolong life and often eventually bring about a cure. Let me say here, if the patients have entered the last stage of the disease, in the interest of humanity keep them at home. This cannot be emphasized too strongly. There they will have more comforts and the radical change of climate, with the long and tiresome journey necessary in reaching here, only tends to materially hasten the end. During the winter months this class of patients, in common with all others, may reasonably expect to hold their own, and usually make substantial gains. It will readily be perceived, by a careful perusal of this article, that there is greater reason to expect beneficial results in all diseased conditions from a sojourn in this climate than in any other winter resort. While this is undoubtedly so, it is equally true that the hot, dry air of summer produces the best results. In heart diseases we find the cooler weather of winter the most beneficial. In some cases the reverse is true. The hotter and drier it gets, the more comfortable the patient becomes. This is especially so where the disease is complicated with diseased kidneys or a rheumatic diathesis. Catarrhal conditions of head and throat are most relieved during the summer, especially the moist varieties. Diseases of the digestive tract, dyspepsia, chronic dysentery and diarrhœa, do exceedingly well here and are usually promptly relieved. This is doubly true during the hot months. The summer conditions, of high temperature and low humidity, cause a determination of blood to the surface, and for months at a time maintaining it there, thereby entirely relieving all internal congestions. Kidney troubles are so prevalent, I must not forget to mention that during the heated term the kidneys excrete less than one-half of the normal quantity of urine. During this period of rest, the unloading of the effete material of the system is carried on by the sweat glands of the skin, and a healthy equilibrium is maintained. This continuous high temperature and very dry air keeps the blood at the surface, thereby making the sweat glands very active. Perspiration is constant and copious, and, by its instant evaporation, keeps the surface cool and the bodily temperature at normal. These conditions are very advantageous to diseased kidneys, giving them a much-needed rest, and an opportunity to recuperate. When to this is added a drinking water pure, wholesome and devoid of all alkali, it is easily understood why this valley is fast getting an enviable reputation for the alleviation and cure of all forms of this disease. In rheumatic affections, while in winter they are made very comfortable, it is in summer that the constant free perspiration maintained for months without ceasing entirely eliminates from the system all morbid material. In diseases of the nervous system, so prevalent in this age, this climate is a true panacea. This is especially so of persons suffering from insomnia and nervous prostration. Here, again, the best results are during the summer months. The universal verdict is, "I have nowhere else slept as I do here." This is the universal expression. The tired out, starved nerves, overworked and overwrought, experience in this balmy air the perfect relaxation and rest they so long have been in need of. The dry, hot air of summer seems to quiet the nervous system, is soothing, restful, and when to this a voracious appetite is added, with perfect digestion, which is the only epidemic during this season, the results are understood without further elaboration. Finally, the perfect summer nights soothe and rest one's nerves as does nothing else in all the world.—The Hahnemannian Monthly.

PIGEON POST MICROGRAPHIC DISPATCHES DURING THE SIEGE OF PARIS, 1870-71.*

A FEW weeks ago the twenty-fifth anniversary of the capitulation of Sedan was celebrated in Germany. At that time the belt which was being made round Paris by the German army was being drawn closer and closer, till at last on September 21, 1870, Paris, the capital, was completely hemmed in. All roads and railways were occupied by German troops, all telegraph lines were destroyed and every communication by land or water was cut off.

There was then but one way left to get out of Paris, and that was through the air. The French, who were the inventors of aerial navigation, did not hesitate long, and on September 23, two days after the city was shut up, the first balloon left Paris and

* Read at the Vienna Photographic Association, October 1, 1895, by Herr Bayer, engineer.

descended safely in the provinces. A regular balloon post was then instituted by Postmaster Rampont. The balloons were made in specially arranged factories, and at intervals of three to seven days balloons continued to leave Paris with a quantity of letters and carrier pigeons, the latter being sent for communication from the provinces with Paris. Letters were written on very thin paper, rolled up and inclosed in a quill, and fastened to a tail feather of the pigeon. Necessarily the pigeons could not be heavily laden, and the news from the provinces was consequently very meager.

It then occurred to the photographer Dagron—well known for his photo-micrographic work—to print all the communications upon large sheets of paper, to reduce them microscopically, and from the negatives to make collodion positives, which he then stripped from the glass. These collodion pellicles being very light, many of them could be sent by a single pigeon.

After arrival of the carrier pigeons in Paris, the positives were to be enlarged by electric light and projected upon the wall of a room specially appointed for the purpose, and the news could then be published throughout Paris by the newspapers. The idea was fully approved by the minister of finance, Picard, also by the postmaster, Rampont, and by decree of November 10, 1870, Dagron was empowered to organize the service in the provinces.

On November 12, at nine o'clock in the morning, the balloon, Le Nièpce, ascended with Dagron and his assistants—Engineer Fanique, Poissot, Guoccni and the aeronaut Pagano. Dagron's apparatus was also packed in the car. At the same time another balloon, the Daguerre, ascended with three passengers, dispatches and photographic apparatus.

Amid sympathetic manifestations of the assembled crowd, both balloons sailed away in a fresh east wind, but the consequences of this expedition were destined to remove the anxiety which reigned in Paris. When the two balloons arrived over the German lines, they encountered a lively fire, and the bullets whistled around them and struck the Daguerre, which fell from its dizzy height upon the wall of some farm buildings near Ferrières, and thus came into the hands of the Germans. This fate would soon have overtaken Dagron's balloon. The sandbags which contained the ballast were torn, owing to the bad material of which they were made, and the sand was lying at the bottom of the car, and could only be thrown out in small quantities. The balloon also was porous, and traveled very low. It was therefore decided to land as soon as possible and place the apparatus in safety. The descent was made without great mishap in the neighborhood of Vitry. The peasants, who hurried to the spot quickly, provided the travelers with blouses and caps for disguise, and scarcely had the apparatus been placed upon two carts when a German patrol arrived and captured the balloon and one of the vehicles. The other got off, and with help of the inhabitants, Dagron and his companions succeeded in reaching Tours on November 21. There they immediately presented themselves to Gambetta, who, as is well known, also escaped from Paris by balloon, and gave notice of the decree.

The government at Tours had meanwhile considered a somewhat similar proposal from the chemist Burreswil, with the intention of carrying it into effect, and, on November 4, had ordered the institution of a photographic dispatch service. The photographer, Blaise, of Tours, commenced the work, but the dispatches were prepared upon paper, two printed pages on each sheet, but the grain of the paper made the reading very difficult, and the whole organization, besides, was very imperfect, so that, from October 26 to November 12, no news whatever reached Paris.

Dagron then demonstrated his process before the post and telegraph master, Steenackers, who had been appointed by the temporary government. It was received with great approval, and the paper process was immediately abandoned.

Dagron's collodion pellicle, besides being lighter and better defined, had also the advantage of greater speed, the exposure being only two seconds, whereas paper prints required two hours for their production. These thin pellicles had also the advantage of being quite transparent and could easily be enlarged by electric light.

With the help of his assistants, Dagron now began the reproduction of the official and private messages. Through the newspapers it became known that the greater part of the apparatus had been lost, and two amateur photographers, Delezenne and Dreux, of Bordeaux, placed similar apparatus at their disposal.

The dispatches were delivered with astonishing quickness; at midday they were printed on large sheets of paper, put together and at five o'clock in the evening ten copies on pellicle were already in possession of the administration.

The pellicles measured about ten centimeters square, each containing a reproduction of twelve to sixteen folio sheets of print, and an average of 3,000 messages. To each pigeon was allotted up to eighteen of these pellicles, therefore more than 50,000 messages, which weighed less than a gramme. The pellicles were rolled up and packed in quills in their usual manner, and their pliability and impermeability to water rendered them specially suitable for the purpose. Some pellicles miscarried thirty-eight times before they reached Paris. The pigeons suffered severely from cold and snow.

The number of private messages was quite astonishing. They were always composed in telegraphic style, and even postal orders and drafts were promptly paid in Paris upon authority of the pigeon post. The total number of messages of all sorts amounted to two and a half millions. The apparatus worked very satisfactorily on the whole, and, when the pigeons were not delayed, the rapidity of communication was excellent. The following is an example:

Dagron was in want of chemicals, especially guncotton, which he could not get in Bordeaux. He therefore ordered them by pigeon post from Poulence & Wittmann, in Paris, on January 18, and asked that they might be sent in the next balloon. On January 24, six days after the dispatch of the pigeon, the goods ordered were delivered to him. The pigeon had flown to Paris in twelve hours. The telegraph and railway could not have done better.

During the siege of Paris, sixty-four balloons in all ascended. Of these two disappeared totally and five fell into the hands of the German army.

Though these balloons also brought a large number of letters to the provinces—about 4,000,000 in all—the chief value of these balloon voyages was attained through the micro-photographic pigeon post. By its means Paris, although completely surrounded by the enemy, was not cut off from the rest of the world, and thousands of families blessed Dagron for his wonderful idea, the accomplishment of which kept them informed of the fate of their relatives in the provinces and with the army; and so, in those days of trouble, the photographic art brought happiness to mankind, as it has done in thousands of other ways.

At the end of the above lecture specimens of the messages were projected on the wall by means of the lantern.

PRESENT STRENGTH OF THE NEW UNITED STATES NAVY.

IN August, 1882, Congress approved an act to complete the double turreted monitors and for the construction of a 6,000 ton protected cruiser. This act was so vague that it was not until March 2, 1883, that Congress appropriated $1,300,000 to begin the construction of four ships. With these ships the new navy was born, and each year since it has been added to until we have now a naval list of nearly a hundred ships in commission, ready to be commissioned or building.

Among this number are five double turreted and thirteen single turreted monitors, six battle ships, one coast defense ship, twenty-five cruisers, one dynamite cruiser, one harbor defense ram, one naval school ship, eight gunboats, six torpedo boats (including one ram and one submarine), one survey and one dispatch boat, besides many vessels of smaller build and efficiency, serving in different capacities where they are respectively stationed.

Of the enumerated vessels, the six battle ships, eighteen cruisers, six gunboats, five torpedo and one dispatch boat, the naval school ship Bancroft, the harbor defense ram Katahdin, the dynamite cruiser Vesuvius and the coast defense ship Monterey, are built of steel.

The eighteen armored monitors, one cruiser, two gunboats, the survey steamer Ranger and the ram Alarm are of iron, while the old wooden ships include six cruisers and the store ship Mohican.

The ships are divided into four classes: (1) Armored, including the battle ships, monitors, cruisers and coast defense ships; (2) unarmored protected vessels, including cruisers, gunboats and dispatch boats; (3) unarmored ships of iron; (4) wood, comprising vessels of the old navy.

The illustrations on other pages will give our readers an idea of the appearance and the proportionate sizes of forty of these new vessels, the earliest built vessels being shown on the page to the left, and those of later construction on the right hand page.

The first-class battle ships Massachusetts and Oregon, on page 16718, are each of 10,231 tons displacement, 9,000 indicated horse power, developing a speed of 16 knots to the former and 16·8 knots to the latter. In armament these two ships are precisely the same, carrying four 13 inch, eight 8 inch and four 6 inch breech loading rifles, sixteen 6 pounder and four 1 pounder quick fire, and four Maxim guns. The second class battle ship Texas has a speed of 17 knots with 8,600 indicated horse power and a displacement of 6,300 tons. She mounts two 12 inch and six 6 inch breech loading rifles, twelve 6 pounder, four 1 pounder quick firing and four Maxim guns.

Of the protected cruisers, the Chicago has a displacement of 4,500 tons, a speed of 15 knots and 5,000 indicated horse power. Her battery contains four 8 inch, eight 6 inch, and two 5 inch breech loading rifles, four quick fire and eight Maxim guns. The Baltimore has a displacement of 4,413 tons and indicated speed of 19 2 knots furnished by engines of 10,750 indicated horse power. Her battery has two 8 inch and six 6 inch breech loading rifles, four 6 pounders, two 1 pounder quick fire and seven Maxim guns. The Philadelphia, with the same displacement as the Baltimore of 4,413 tons, has made 19 knots with 10,500 indicated horse power. She mounts twelve 6 inch breech loading rifles, four 6 pounder, four 1 pounder quick fire and 7 Maxim guns. The San Francisco has displacement of 4,083 tons, a speed of 19·5 knots and engines of 10 500 indicated horse power. She carries twelve 6 inch breech loading rifles, four 6 pounder quick fire and seven Maxim guns.

The Atlanta and Boston have each a displacement of 3,189 tons. The Atlanta has a speed of 15·4 knots, attained by 3,511 indicated horse power; the Boston requiring 3,780 indicated horse power to attain a speed of 15 knots. On both of these ships the batteries are the same, consisting of two 8 inch, six 6 inch breech loading rifles, 6 quick fire, and 6 Maxim guns.

Of the unprotected cruisers, the Minneapolis has developed a speed of 23·073 knots, with engines of 21,000 indicated horse power. Her displacement is 7 475 tons, she carries one 8 inch and two 6 inch breech loading rifles, eight 4 inch rapid fire, twelve 6 pounders, eight 1 pounder quick fire, and four Maxim guns.

The Cincinnati and Raleigh are government productions, having been built the former at the Brooklyn navy yard and the latter at the Norfolk yard. They are of 3,183 tons displacement, 10,000 indicated horse power, and a speed of 19 knots each. The Cincinnati carries one 6 inch and ten 4 inch breech loading rifles, two 6 pounders, two 3 pounder quick fire, and four Maxim guns. Mounted on the Raleigh are one 6 inch breech loading rifle, ten 5 inch rapid fire, eight 6 pounder, four 1 pounder quick fire, and two Maxim guns.

The gunboat Yorktown, one of the first four ships authorized, has a displacement of 1,700 tons, an indicated horse power of 3,400, develops a speed of 16 knots, mounts a battery of six 6 inch breech loading rifles, four 6 pounder quick fire and five Maxim guns.

After building and commissioning the next two gunboats Machias and Castine, they were found to be too topheavy in a seaway. To rectify this defect it was decided to lengthen them. Accordingly the two vessels were cut in two amidships and rebuilt, thus righting the blunder originally made. In these two vessels there is but one point of difference, the Machias having a speed of 14·5 knots, from 1,600 indicated horse power engines with a displacement of 1,050 tons, where the Castine makes but 14 knots with the same horse power and displacement. In armament the two vessels each carry eight 4 inch rapid fire, four 6 pounder, two 1 pounder quick fire and two Maxim guns. The Petrel is of 890 tons displacement, has a speed of 13 knots, engines of 1,300 indicated horse power, a battery of four 6 inch breech loading rifles, three 3 pounder quick fire and four Maxim guns.

The coast defense double turreted ship Monterey has a displacement of 4,048 tons, a speed of 16 knots, engines of 5,400 indicated horse power.

Mounted in her two turrets are two 12 inch and two 10 inch breech loading rifles, with a lighter battery of six 6 pounder, four 1 pounder quick fire and four Maxim guns, mounted on the superstructure and in the fighting top.

The harbor defense ram Katahdin carries but a light secondary battery of four 6 pounder quick fire guns. She has a displacement of 2,050 tons, a speed of 17 knots, and engines of 4,800 indicated horse power. The dynamite cruiser Vesuvius has a displacement of 725 tons, a speed of 21 knots, and engines of 3,200 indicated horse power. She was designed to throw 600 pound charges of dynamite from her 15 inch pneumatic guns, which are supplemented by three 3 pounder rapid fire guns. The torpedo boat Cushing is of 116 tons displacement, has engines of 2,500 indicated horse power, and a speed of 22·5 knots per hour.

Among the vessels shown on page 16719, the Iowa stands first with a displacement of 10,286 tons, indicated horse power of 11,000 and a contract speed of 16·5 knots. When ready for active service, the Iowa will carry a battery of four 12 inch and eight 8 inch breech loading rifles, six 4 inch rapid fire guns, twenty 6 pounder, six 1 pounder quick fire and two Maxim guns. The Indiana, now nearing completion, is one of the three heaviest vessels which at present are on the naval list. She has engines of 9,000 indicated horse power, a speed of 16 knots and a displacement of 10,231 tons. In armament and construction she is the counterpart in every particular of her sister ship Massachusetts. Her battery will have four 13 inch, eight 8 inch and four 6 inch breech loading rifles, sixteen 6 pounder, six 1 pounder quick fire and four Maxim guns. The second class battle ship Maine has a displacement of 6,648 tons, a speed of over 17·7 knots and engines of more than 9,000 indicated horse power. She has four 10 inch and six 6 inch breech loading rifles, with a secondary battery of twelve 6 pounder, four 1 pounder quick fire and four Maxim guns. The cruiser Brooklyn, now on the stocks, is an improved model of the New York. She is to have a speed, according to contract, of 21 knots, to be of 16,900 indicated horse power and have a displacement of 9,250 tons. Her batteries will be eight 8 inch breech loading rifles, twelve 5 inch rapid fire, twelve 6 pounder and four 1 pounder quick fire, four Maxim guns and two light or field pieces.

The New York has a speed of 21 knots, triple expansion engines of 16,000 collective indicated horse power, and a displacement of 8,150 tons. Her armament consists of six 8 inch breech loading rifles, twelve 4 inch rapid fire, eight 6 pounder, four 1 pounder quick fire, and four Maxim guns. The Newark has a displacement of 4,083 tons, an indicated horse power of 8,500, driving her at the called for speed of 19 knots. In armament she is inferior to the Chicago, carrying twelve 6 inch breech loading rifles, four 6 pounders, quick fire, and nine Maxim guns. The Charleston has a displacement of 3,730 tons, engines of 7,500 indicated horse power at a contract speed of 17 knots. Mounting batteries of two 8 inch and eight 6 inch breech loading rifles, four 6 pounder, two 3 pounder quick fire, and eight Maxim guns.

In the Marblehead and Montgomery the government contract calls for two ships of the same dimensions and armament, with displacements of 2,000 tons, engines of 5,400 indicated horse power, driving the ships at a speed of 18·3 knots. The batteries of these two ships comprise two 6 inch breech loading rifles, four 4 inch rapid fire, four 6 pounder, three 3 pounder quick fire, and two Maxim guns.

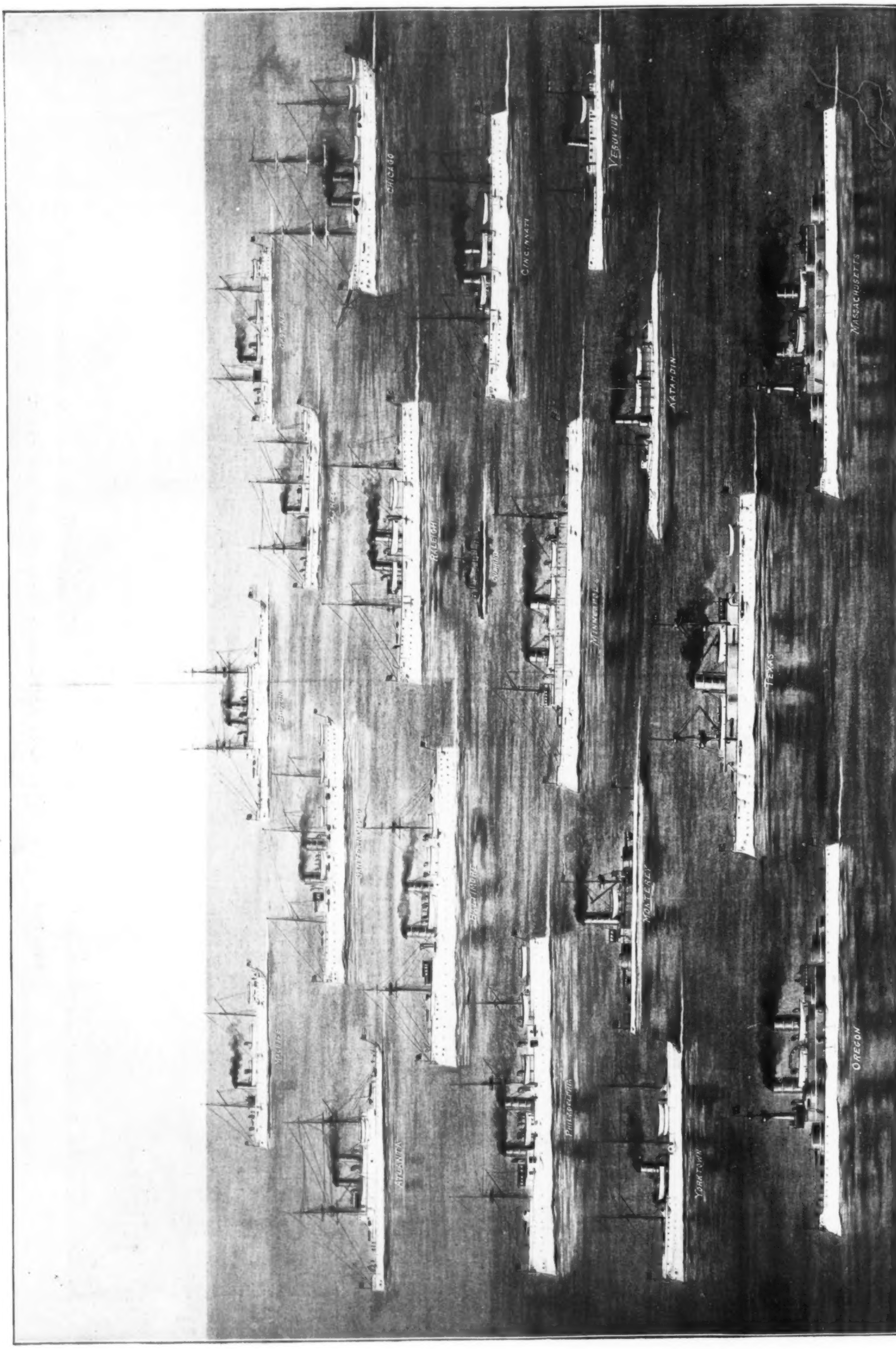
The Concord and Bennington are similar ships in all but their displacement, the latter being 1,750 to the former's 1,700 tons displacement, with indicated horse powers of 3,400 and called for speed of 17 knots. In armament these two ships are identical, mounting six 6 inch breech loading rifles, four 6 pounder quick fire, and five Maxim guns.

The Columbia has a displacement of 7,475 tons, engines of 21,000 indicated horse power and a speed of over 22 knots. She is probably the fastest cruiser in the world. In armament the Columbia and Minneapolis are identical, carrying one 8 inch, two 6 inch breech loading rifles, eight 4 inch rapid fire, twelve 6 pounder, eight 1 pounder quick fire and two Maxim guns. The Olympia, with a displacement of 5,500 tons and engines of 13,500 indicated horse power, has a speed of 20·2 knots. In her batteries she carries four 8 inch breech loading rifles, sixteen 5 inch rapid fire, fourteen 6 pounder, six 3 pounder quick fire and four Maxim guns. Among the first of the new ships, the Detroit was built on a contract calling for a displacement of 2,000 tons, driven by engines of 5,400 indicated horse power at a speed of 18 knots. She mounts two 6 inch breech loading rifles, four 3½ inch rapid fire, four 6 pounders, two 1 pounder quick fire and two Maxim guns.

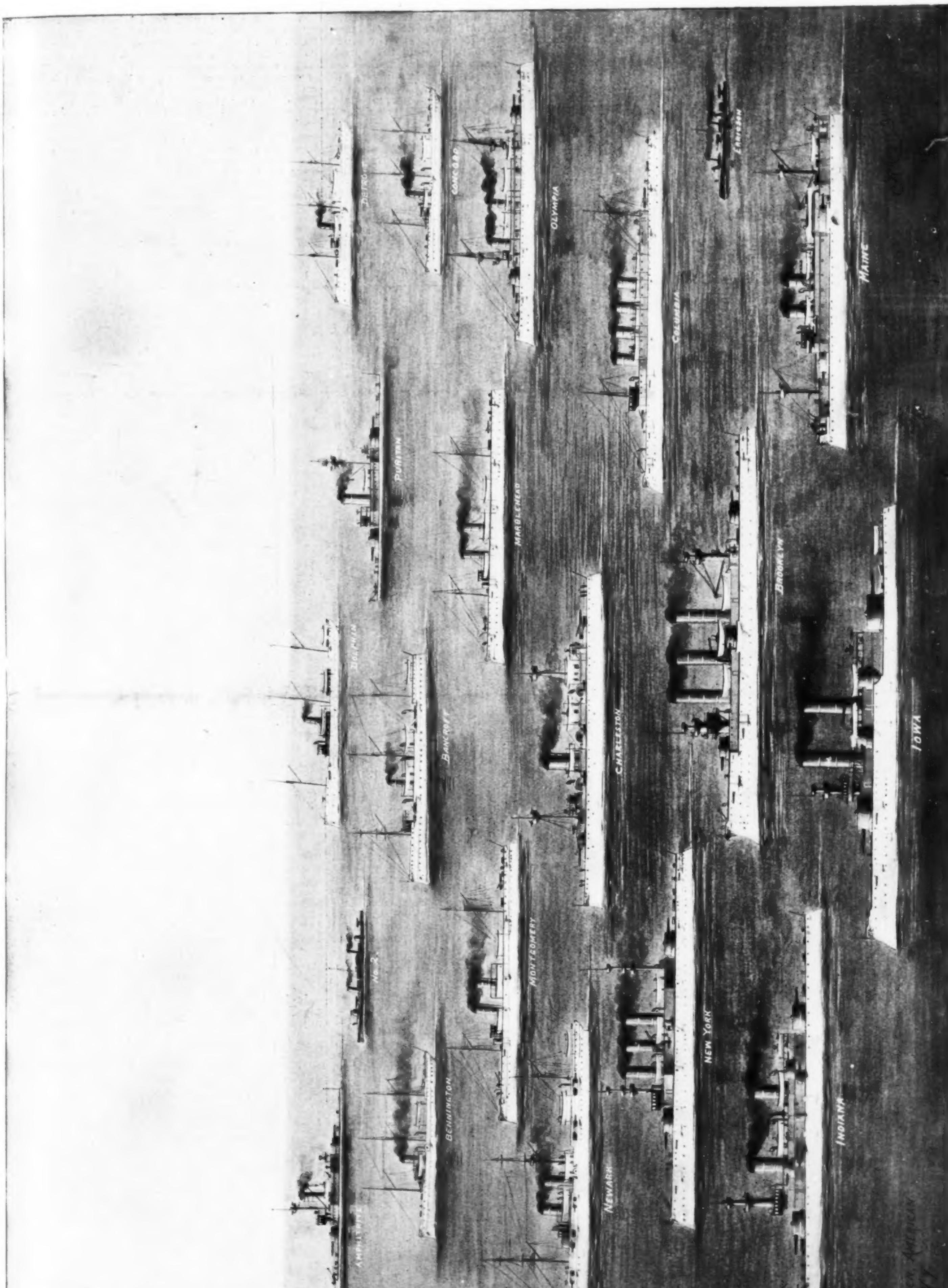
Among the vessels commissioned in 1894 was the naval training ship Bancroft, of 838 tons displacement, with engines of 1,300 indicated horse power, developing a speed of 13 5 knots. For practice and drill her batteries comprise four 4 inch rapid fire, two 6 pounder, two 3 pounder, one 1 pounder quick fire, and two Maxim guns.

The Dolphin, which was one of the first four ships contracted for of the new navy, is of 1 485 tons displacement, with engines of 2,300 indicated horse power and a speed of 15·5 knots. She is now the dispatch boat of the United States navy, carrying but a light armament comprising two 4 inch rapid fire, two 6 pounder quick fire and six Maxim guns.

Of the monitors, the Puritan, with two turrets mounting four 10½ inch breech loading rifles, four quick fire and eight Maxim guns, with a displacement of 6,000 tons and indicated horse power of 3,700, at-



THE NEW UNITED STATES NAVY—COMPARATIVE DIMENSIONS OF THE VESSELS.



THE NEW UNITED STATES NAVY—COMPARATIVE DIMENSIONS OF THE VESSELS.

taining a low speed of 13 knots, is the largest and heaviest of her type.

The Amphitrite, another of the monitor class, carries four 10¼ inch breech loading rifles in two turrets, with a secondary battery comprising six quick fire and four Maxim guns; she has a displacement of 3,990 tons, and engines of 1,600 indicated horse power, developing a 12 knot speed, and is one of three ships of this class that stand next to the Puritan.

The torpedo boats Ericsson and the one now known as No. 2 are greatly different in size, the former having 750 tons displacement against No. 2's 120. These little fliers have a speed of 23 knots in the Ericsson and 24 in No. 2.

THE HARBOR DEFENSE RAM KATAHDIN.

WE illustrate in this issue the ram Katahdin, the last accession to the United States navy. The Katahdin had her official trial on October 31, 1895, over the Long Island Sound course, completing 17 knots in one direction in 1 hour, 5 minutes, 32 seconds, and the return trip in 1 hour, 0 minutes, 44 seconds. When corrected the results gave her unofficial speed of but 16·11 knots—far below the requirements. Her engines showed about 200 horse power over the contract requirements. This result of the trial trip threw the vessel back upon the builders' hands. Various pleas were entered in their defense, based on the new type of vessel, its real value even at the reduced speed, and a bill providing for her acceptance was passed by Congress, and on January 9, 1896, the formalities for her acceptance were concluded and the new ram will soon be in commission.

The Katahdin is a twin screw armor plated vessel, built from the designs of Rear Admiral Daniel Ammen, and is based upon the personal experience of the admiral in the use of and the defense against rams in our civil war, 1861–65. The plans were made in the Bureau of Construction and Repair, under the supervision of Commodore T. D. Wilson, in consultation with Admiral Ammen, and the machinery was designed in the Bureau of Steam Engineering, under the supervision of its chief, Commodore George W. Melville. The bids for her construction were opened at the Navy Department on December 20, 1890. There was one bidder only, the Bath Iron Works, and on January 28, 1891, the contract was awarded to this company to build and equip the vessel and machinery and to place the armor for $930,000, to be completed by July 28, 1892.

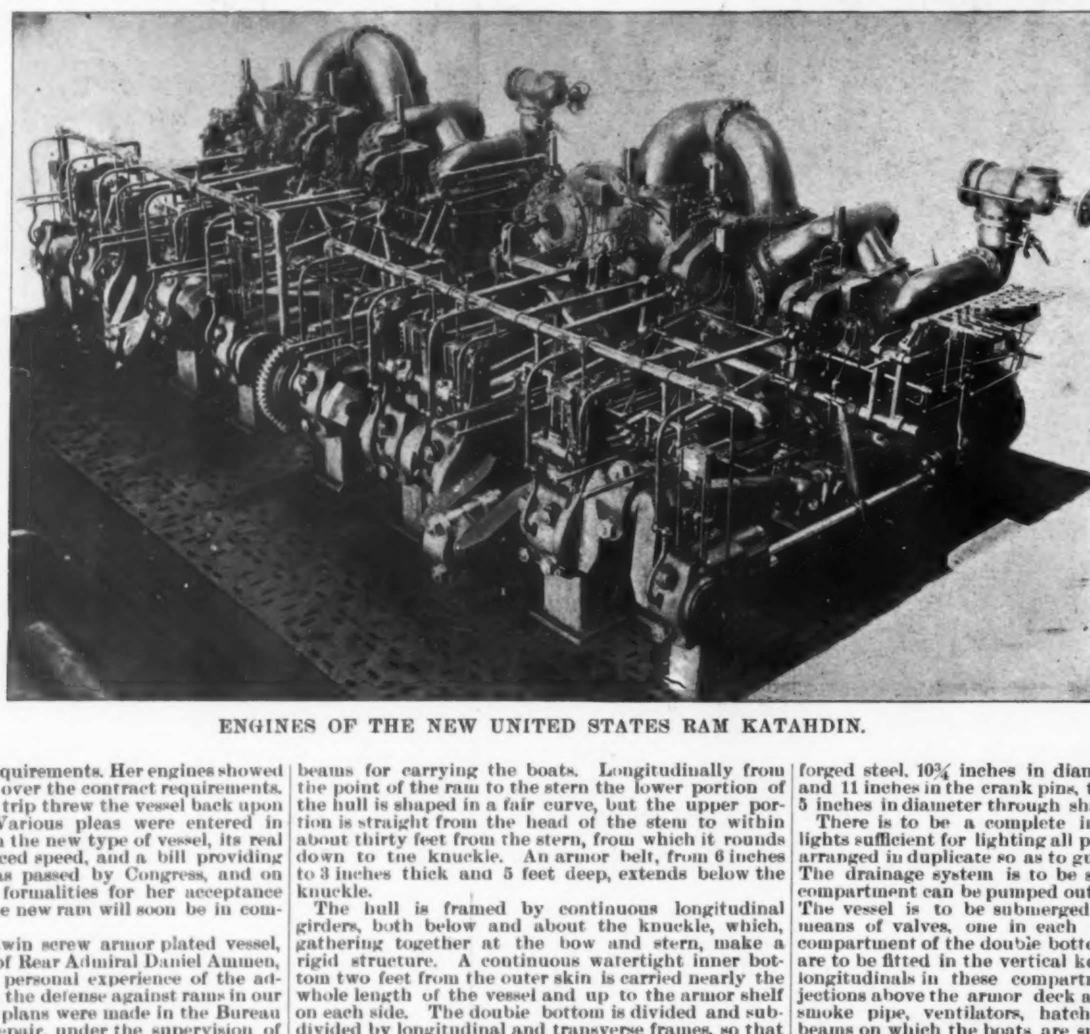
On March 27, 1891, the Navy Department approved the proposition of the contractors to lengthen the vessel eight feet, the corresponding increase in the displacement (133 tons) to be utilized in increasing the coal supply and providing a battery of four 6 pounder rapid-firing guns for defense against torpedo attack, the original design having no battery whatever. The type and size of the boilers were also modified. With these changes the dimensions of the vessel are as follows: Length over all, 251 feet; length on the normal water line, 250 feet 2 inches; extreme breadth, 43 feet 5 inches; breadth on water line, 47 feet 6 inches. The total depth from the base to the crown of deck amidships is 22 feet 10 inches, and the normal draught of water is 15 feet, the corresponding displacement being 2,155 tons. The lower portion of the hull is dish shaped up to a sharp knuckle, which runs all around the vessel 6 inches below the normal water line, the angle of the knuckle amidship being about 90 degrees. Above this knuckle the shape of the hull is a circular arc, with a radius amidship of 39 feet, rising from 6 inches below to 6 feet above the normal water line. This curved deck is armor-plated throughout, the thickness of the armor tapering from 6 inches at the knuckle to 2 inches at the crown of the deck. Above this deck is a conning tower of 18-inch plate, a smokepipe and ventilators, and two light barbettes, within which the guns will be mounted, and skid beams for carrying the boats. Longitudinally from the point of the ram to the stern the lower portion of the hull is shaped in a fair curve, but the upper portion is straight from the head of the stem to within about thirty feet from the stern, from which it rounds down to the knuckle. An armor belt, from 6 inches to 3 inches thick and 5 feet deep, extends below the knuckle.

The hull is framed by continuous longitudinal girders, both below and about the knuckle, which, gathering together at the bow and stern, make a rigid structure. A continuous watertight inner bottom two feet from the outer skin is carried nearly the whole length of the vessel and up to the armor shelf on each side. The double bottom is divided and subdivided by longitudinal and transverse frames, so that there are seventy-two watertight compartments. The inner hull is further subdivided by watertight bulkheads, both longitudinal and transverse.

The ramhead is of cast steel, extending back eleven feet in a vertical line, and it is supported by longitudinal braces in such a way that the force of the blow delivered by it is designed to be distributed through the vessel. The maximum estimated speed, at full power, was seventeen knots, and the impact of the ram at this speed being equivalent to the blow of a hammer weighing over two thousand tons moving at this rate of speed—a blow which, if fairly delivered, would crash through the sides of any vessel afloat.

The quarters for the officers are on the after berth-deck, just abaft the engine room bulkhead, and the wardroom has seven staterooms and a pantry. The forward berth-deck is designed entirely for the crew, but there is an apartment abaft the officers' quarters which may be used as additional berthing space for a portion of the crew.

There are two engines, horizontal, direct acting, triple expansion, driving twin screws, the cylinders 25, 36, and 56 inches diameter respectively, and with 36 inches stroke, common, with 4,800 horse power when making 150 revolutions per minute. The main steam valves are of the piston type, one for each high and intermediate and two for each low pressure cylinder, driven by Marshall radial gear, with compensating rock shafts, and all the valve gear except the rock shafts being interchangeable. The engine keelsons are built in the ship and the cylinders cast with brackets attached to be bolted together and to the keelsons. The cylinders are also attached by forged steel tie rods to the bed plates and engine frames. There is one forged steel piston rod for each engine, with a crosshead working on a cast iron bar guide, the valve stems being of forged steel. The crank shafts are in two sections for each engine, of mild forged steel, 10¾ inches in diameter in the journals and 11 inches in the crank pins, there being axial holes 5 inches in diameter through shafts and pins.

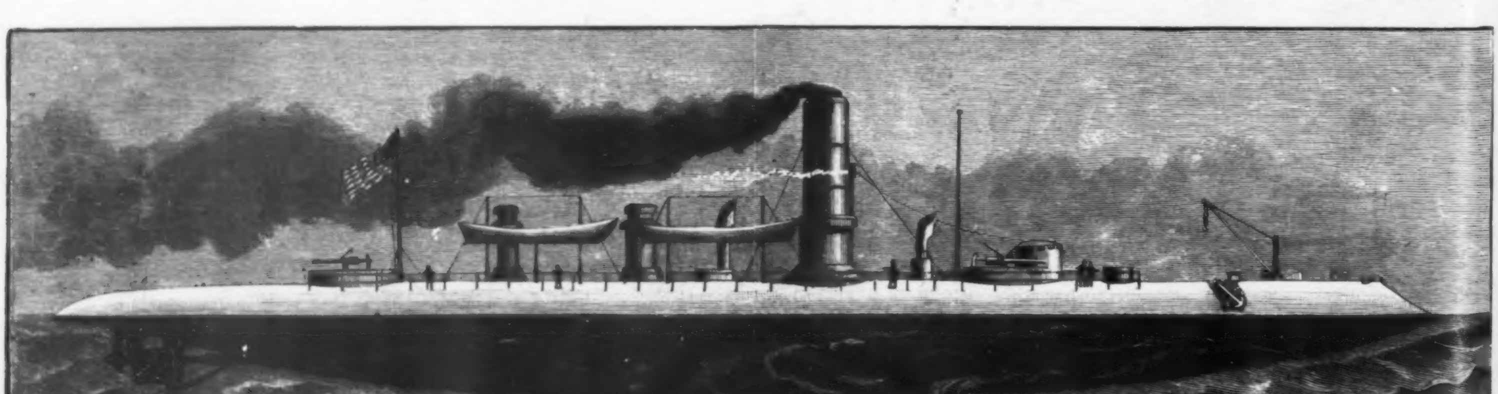


ENGINES OF THE NEW UNITED STATES RAM KATAHDIN.

There is to be a complete installation of electric lights sufficient for lighting all parts of the vessel, and arranged in duplicate so as to guard against accident. The drainage system is to be so arranged that any compartment can be pumped out by the steam pumps. The vessel is to be submerged to fighting trim by means of valves, one in each transverse watertight compartment of the double bottom; and sluice valves are to be fitted in the vertical keel and the watertight longitudinals in these compartments. The only projections above the armor deck are the conning tower, smoke pipe, ventilators, hatch coamings and skid beams on which the boats are supported. The vessel has no armament, and is to rely entirely on the ramming for her offensive power.

PEACHE'S HIGH SPEED ENGINE.

IT is stated that at the present moment it is impossible to place an order for a high speed engine with any makers of repute, their order books being full for months to come. The advent, then, of a new high speed engine which has already proved that it is economical and trustworthy is a matter for congratulation. The engine in question has been invented and patented by Mr. J. C. Peache, whose long experience with Messrs. Willans & Robinson renders him a high



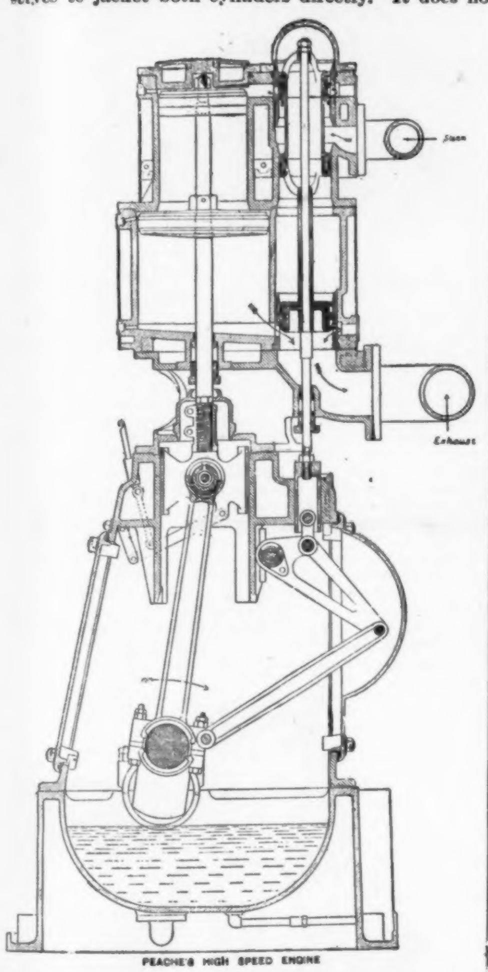
THE HARBOR DEFENSE RAM KATAHDIN, ACCEPTED BY CONGRESS JANUARY 9, 1896.

authority on high speed engines, and is made by Messrs. Davey, Paxman & Company, of Colchester, who, during the last eighteen months, have carried out exhaustive trials before placing the engine in the market. Our illustration shows one of three sets which have been at work driving Mordey alternators at the Indian Exhibition, Earl's Court, throughout the summer.

It was shown many years ago that if a successful high speed steam engine was to be made, it must be single acting, so that the pressure on the crank pin would always be in one direction. Very shortly afterward the first successful high speed engine was made on the lines we indicated, and since then a multitude of patents have been taken out, all for single acting engines, and all with devices for maintaining constant pressure in one direction. This has been got either by giving much lead or by the use of a separate piston and cylinder in which air is compressed. Mr. Peache uses a somewhat different device; but the valve gear of high speed engines presents difficulties of construction, and unless special precautions are taken, it can prove very noisy and troublesome. Mr. Peache dispenses altogether with an eccentric, in a way which we may now proceed to explain.

The crank shaft runs in a chamber holding oil and water as is usual for lubrication, and presents nothing new. No steam can find its way into this chamber, unless such as may leak past the lower stuffing box.

It will be seen from the section that the two cylinders are quite open to each other, and the space between is kept full of boiler steam admitted through a small orifice not shown in the engraving. The steam serves to jacket both cylinders directly. It does no



PEACHE'S HIGH SPEED ENGINE

work in one sense. It tends always to force the pistons down by the amount due to the difference in area of the two pistons, and as one is much larger than the other, it will be seen that there is a constant pressure downward on the crank shaft. This prevents knock, and is the equivalent of the air cylinder in Messrs. Willans & Robinson's engine. The valve gear is extremely simple. A bell crank lever worked off the crank shaft actuates a piston valve; as there is always pressure on the top of the lower piston valve, there can be no knock in the valve gear. The distribution is very simple. Steam is admitted above the high pressure piston. The engine makes its down stroke under the action of the steam above the high pressure and low pressure pistons. When the lower center has been crossed, steam is passed from above the high pressure below the low pressure piston, and the engine then makes its upstroke. When the top center has been reached, as in our section, the steam exhausts as shown.

The crank shaft is put out of the center line of the cylinder, as in the Westinghouse high speed engine, in order to get a direct down thrust during the working stroke and to secure a better action of the valve gear.

At Earl's Court two of the three engines have six cylinders; the third, four cylinders only; the latter driving a 75 kilowatt Mordey alternator, develops 150 horse power at 355 revolutions. The other two run at 335 revolutions, and develop 220 horse power on 100 kilowatt Mordey alternators. The cylinders are of the same dimensions in all the engines, 10 inch + 15 inch × 10 inch.

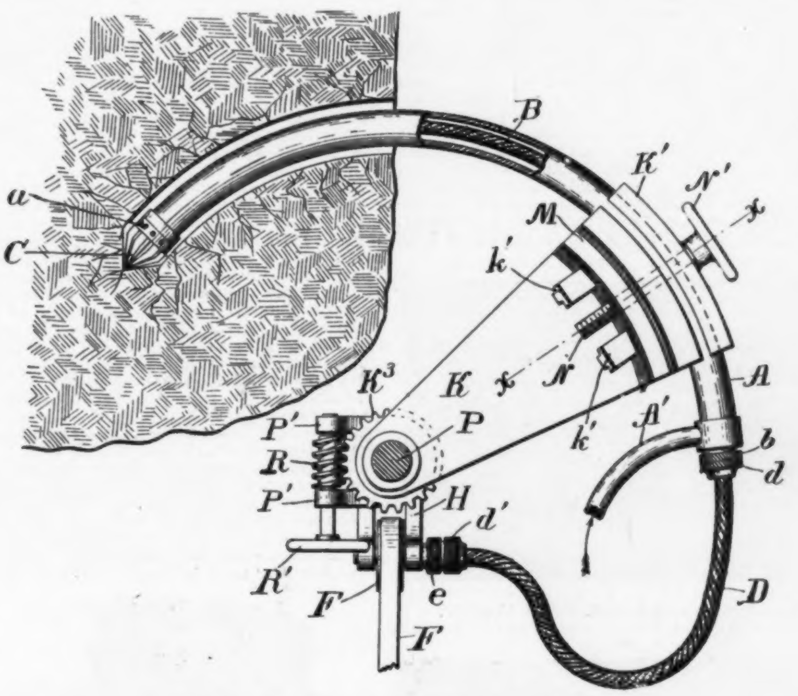
The only test of which we have particulars was one carried out at Colchester, when we understand the steam consumption was 22 lb. per horse per hour, a capital result for a non-condensing engine, and the brake horse power was 88 per cent. of the indicated. —The Engineer.

DRILL FOR BORING CURVED HOLES.

ROBERT H. ELLIOTT, of Birmingham, Ala., and John B. Carrington, have invented the new drill for boring curved holes which we here illustrate. A represents a pipe of the desired curvature, perforated at its forward end, to deliver into the bore hole the air, water, or other fluid which is fed in through the pipe, A, for the purpose of blowing or washing out the chips and cooling the drill.

B, wire rope, connected to drill or boring tool and connected by the wire rope, D, and shaft driven by pulley, E, and belt, F. Thus motion is transmitted from the said belt to the boring tool, C.

Pipe, A, is clamped in the sector, K, journaled on the jack post, P, and has rigidly connected to itself the worm wheel, K^3, in which meshes the worm, R, operated by hand wheel, R'. By means of this hand wheel, feed motion is given to the pipe, A, and the boring tool, C, and the boring tool may be withdrawn either by reversing the motion of the hand wheel, R', or by swinging the sector, K, by hand about the jack post, P.



DRILL FOR BORING CURVED HOLES.

MILLING MACHINE FOR PREPARING TEST PIECES.

THE machine which we illustrate on the present page is self-contained, and is specially designed for milling at one operation both edges of test pieces to uniform sizes after they are cut from the plates to be tested. It will operate at one setting upon any number of test pieces up to 18 in. long, 3½ in. wide, making up a total depth of not more than 12 in.

The machine is of a strong and substantial form, and consists of a heavy bed, supported on three standards, having accurately planed and scraped vees at each end 24 in. across the face. Upon this slide the two carriages carrying the spindles, to which are fixed the cutter heads. The carriages are adjusted to and from each other by means of a revolving nut and stationary screw fixed in the bed, the nuts being actuated by means of × handles seen on the illustration. The spindles are of steel, and run in adjustable parallel gun metal bearings. They are screwed one right hand and one left hand to receive the cutter heads, and are also arranged with adjustable collar and lock nuts at the back end to take up any end wear, and thus prevent the cutters digging in. The cutter heads are 15 in. in diameter, and are each arranged to receive eight cutters, which are adjustable to and from the center. The cutters are firmly held in position by means of steel set screws. These screws work in steel bushes, and in case the thread wears, the bush can be taken out and a new one put in its place, so that the durability of the cutter head is not interfered with. In the center of the bed is situated the slide, in which works the combined cross carriage and vise, and this is so arranged that no cuttings can fall on to the working parts of the slides, the carriage being made wide enough to cover these, so that all the cuttings fall clear. This carriage is arranged with a self-acting cross traverse of 21 in. by means of a three-speed cone, worm, and worm wheel (the worm running in an oil well), and screw, quick hand traverse by swape and self-acting stop motion arranged to knock off at any part of its traverse. The vise is arranged with two straps at the top and two at the bottom; these are adjustable to suit the various widths of the test pieces, which are reared against them when placed in the machine. The test pieces are securely locked against each other by means of two steel set screws. To prevent the vise being sprung over to one side when there is a larger cut on one side than the other, the top is accurately planed and scraped, and works in a slide fitted with adjustable slips, which is supported on the front bearings of the spindle carriages.

The machine is driven by means of a three-speed cone 4 in. wide, through spur gear of ample power, having a purchase of 16 to 1, all the pinions being made of steel. At the opposite end of the machine to the driving cone is the pump, which is provided with an

MILLING MACHINE FOR PREPARING TEST PIECES.

air vessel, so as to deliver a continuous supply of suds upon the cutting tools.

The machine, complete with overhead driving motion and screw keys, weighs 3 tons 18 cwt., and is constructed by messrs. Ward and Haggas, of Eastwood Tool Works, Keighley. We are indebted to our English contemporary Engineering for the engraving and description of this machine.

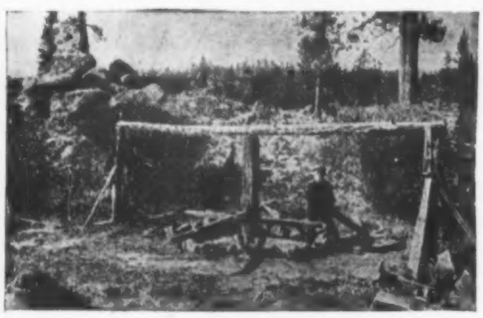
[Continued from SUPPLEMENT, No. 1045, page 16704.]

NOTES ON GOLD MILLING IN CALIFORNIA.*

By ED. B. PRESTON.

GRINDING AND AMALGAMATING MACHINES.

ARRASTRAS.—Although the arrastra has been largely superseded by the stamp mill, the fact remains that it is the best and cheapest all round gold-saving appliance we have. Hence, its use is always indicated where small, rich veins are worked in the higher mountain regions, but it is also found valuable placed below the present quartz mill, where the waste waters from the mill can be picked up and used over again for power on horizontal or overshot wheels. In these cases it handles the tailings from the mill after they have passed over the concentrators and canvas plants. This part of the milling is usually leased to parties who pay the mine a fixed amount per ton for the tailings, the lessees putting up all their own machinery. These arrastras are built of a size to handle at least four tons of tailings in twenty-four hours. Their foundations are either formed of hard rammed clay, concrete, or a plank platform with broken joints, on which a bed of clay is placed. The foundation is always made larger than the circumference of the proposed arrastra. The bed is formed of rocks harder than the substance to be crushed, usually fine grained basalt, granite or quartzite. These are picked with a partially level surface, and as near of the same thickness as possible, usually from 1 ft. to 2 ft. thick. They are built around a center cone, forming an annular ring from 2½ ft. to 6 ft. wide, and are laid with narrow spaces between each rock, into which dry clay should be tightly rammed to within an inch of the surface. The outer circle is formed of rocks or staves, with rammed earth behind, and built from 2 ft. to 4 ft. in height. On the central cone, which consists of stone or a block of wood, and which stands somewhat above the paved bottom, a center post is let in, from which project four arms at right angles to each other, and extending nearly to the outer circle. Heavy, hard rock drags, weighing from 200 to 1,000 lb. each (from 400 to 600 lb. is the usual weight), are attached to the arms by ropes or chains passing through eye bolts secured in the rock drags. They are placed so that part of them drag near the cone, with the inside corner slightly in advance, while the remainder sweep near the outer circle with the outer corner in advance. The front edge should always be slightly elevated so as to permit of the particles passing under the drag instead of being pushed ahead.



HORSE POWER ARRASTRA, KERN COUNTY.

WATER POWER ARRASTRA, KERN COUNTY.

STEAM POWER ARRASTRA, KERN COUNTY.

Where a horizontal wheel is used, the arms are attached to the center post and the wheel encircles the arrastra, the water striking on buckets set to an angle of 45°. With overshot wheels the arrastra may be run by a belt and pulley attached to the center post, or by a spur gearing. It requires about 6 horse power to run an average-sized arrastra. Running tailings, a speed of 15 to 30 revolutions per minute is given; crushing ore, the arrastra should be run slower and the pulp thicker.

For discharging the arrastra, plug holes at different levels are put into the outer circle, leading the pulp into sluices lined with plates, riffles and blankets. In some cases the arrastra has been made to work continuously by fitting a screen to a part of the outer circle and letting it discharge into a line of sluices. As the arrastra bottom and drags are extremely uneven and rough when first set up, some coarse sand and water are introduced on first starting, and the drags are allowed to run slowly until somewhat smoothed down before the regular charge is introduced. The machine is usually only cleaned up thoroughly when the bottom is worn away; between times the crevices are picked out for the depth of an inch or two with picks, scrapers and spoons, and panned out, with what pulp remains on the bottom, after the charges have been successively thinned down and run off through the plug holes. If crevicing has been done, a little fresh clay can be rammed into within 1 in. of the top of the bed. During the grinding of the charge, the quicksilver is introduced through a cloth: the amalgam should be kept drier than in the stamp battery, though not sufficiently so as to become "crumbly." Great attention must be paid to tamping the bed in solid, otherwise an excessive loss of quicksilver may occur. Continual horn tests of the pulp furnish a guide for the proper working.

Machines have, from time to time, been introduced in California to replace stamps, claiming to do more effective work, both as regards the crushing as well as the amalgamating. Those mostly seen in operation, and finding the most favor, are the Huntington and the Bryan mills, which may be taken as types, and which reduce the ore by a continuous rolling motion; in the one case the roller acting on a ring on the circumference and in the other on dies in the bottom.

The Huntington mill consists of a shallow iron pan with a central cone, through which an iron shaft revolves. Bolted on the sides of the pan and inclosing it are semicircular iron sections made in two halves and also bolted together; one of these sections contains an opening about 9 in. deep, divided into three parts, into which curved iron screen frames are keyed, while the other section contains a feed trough attached near the top. Between the bottom of the pan and the lower edge of the screen frames an iron or steel ring die fits against the sides of the shallow pan, being secured by wooden wedges; against this die four rollers, suspended from yokes resting on an iron cover, revolve, receiving their motion from the central shaft. These suspended rollers are pressed by centrifugal force against the ring die. Each roller is encircled by an iron or steel shoe fastened by wooden wedges; this can be renewed when worn too thin or when it becomes unround—flattened. Means are provided for lubricating the shafts on which the rollers work, without permitting the lubricant to come in contact with the pulp. As the rollers hang about ½ in. above the bottom of the pan, scrapers are attached to the revolving cover between the rollers, and reaching to the bottom of the pan, to prevent the breaking of the pulp.

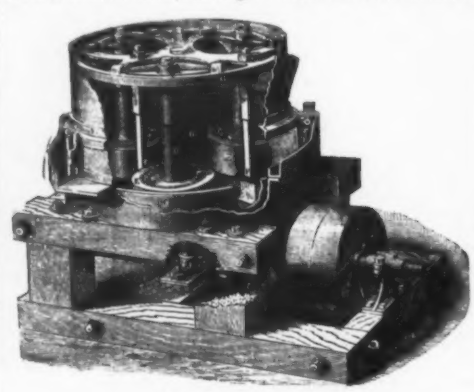


FIG. 42. THE HUNTINGTON MILL.

The size of the pan most frequently used is 5 ft. in diameter, though for prospecting purposes one of 3½ ft. is also made; the former is run at a speed of 70 revolutions per minute, the latter at 90 revolutions. They are provided with self-feeders, which introduce the ore at regular intervals—the only way in which they can be operated, though not correct in principle. A 5 ft. mill requires about 8 horse power and crushes about 20 tons per day. Before starting a certain amount of quicksilver, up to 50 lb., is introduced into the pan with some water and rock. The supply should be regulated to make a stiffer pulp than in a stamp battery; quicksilver is added from time to time. A groove in the bottom of the pan, connecting with a plug hole on the outside, permits of the quicksilver and amalgam being drawn off at intervals to recover the latter, after which the former is returned. If the pan is working correctly, the bottom around the center remains bare; this can be observed through the cover while running; when not bare, it is a sign that the pan is being overfed. As the machine throws the pulp with considerable violence through the curved screens, a shield is placed outside of them, directing the pulp into a narrow sluiceway with a spout opening on the apron plate. It is claimed that the percentage of gold amalgamated and saved on the inside is far greater than in the stamp mortar, going above 80 per cent., all rusty gold being subjected to a heavy scouring action. The Russian iron screens used are short lived; they can be made to last somewhat longer by placing a false screen, made from an old worn screen with the openings enlarged, between the pulp and the screen proper.

Great care must be exercised in putting up one of these machines to get it perfectly level and on a rigid foundation, and to keep all the bolts holding the pan on the foundation well tightened up; the feed also requires close observation.

When cleaning up or renewing the ring dies or shoes, the top cover, with the suspended rollers, is lifted out with chain block and tackle, leaving the interior of the pan free for operation.

The mill works well on soft quartz and clayey ores, introduced in pieces not larger than walnuts. A great drawback to the machine is that the rings on the rollers and also the dies become "unround," so that instead of rolling smoothly, they strike in places, necessitating changing the rings before they are worn out; this changing takes up some time.

The opinions of millmen who have handled the Huntington mill, as to its merits, are very diverse. Where the ore produces a large amount of fine stuff, by using a grizzly with closely set bars, the Huntington can be run to advantage on these "smalls" in conjunction with the stamps.

The Bryan roller mill is a modified form of the Chile mill, built in sizes of 4 ft. and 5 ft. diameter. It consists of an annular mortar with an outside gutter and spout, cast solid, containing steel dies arranged in the track of three crushing rollers, which in the 5 ft. mill have a crushing face of 7 in., a diameter of 44 in., and weigh 3,650 lb. They have fixed axles, "journaled" in a central revolving table attached to and driven by a belt pulley. This pulley is a cylindrical tank, which, in the smaller pattern, rests immediately on the rollers, and can be made to increase their crushing power by being loaded. The mortar is supplied with curved screen frames around the entire machine, the pulp being discharged all around into a gutter delivering through a spout, on one side, to an apron plate.

FIG. 43. THE BRYAN MILL.

The chief wearing parts are the steel dies and tires on the rollers; these latter are fastened to the rollers by wooden wedges. According to the statement of the manufacturers (Risdon Iron Works, San Francisco), one set of these wearing parts will crush from 4,000 to 8,000 tons of ore in the large size and 1,500 to 2,000 tons in the smaller size, and at the rate of 25 to 35 tons and 12 to 20 tons per day, with a speed of 30 and 60 revolutions respectively per minute, the smaller size requiring from 5 to 6 H. P. The oil channels for lubricating the bearings are arranged to prevent the oil from entering the mortar. To keep the pulp from baking to the rollers or dies, and to assist in equalizing the ore received from the feeder, scrapers with adjustable springs follow each roller. They are also provided with self-feeders. In operating the mill, ore, water, and mercury are introduced into the mortar, the pulp passing around next the screens in a current not less than 300 ft. per minute, while the motion inside of the rollers is much slower. The amalgam, working its way toward the center cone, is kept from being reground, and can be observed while the mill is in operation; it is claimed to retain 80 per cent. of the amalgam in the mortar. To clean it up, the dies between the rollers are removed, the pulp and amalgam taken out, and wooden blocks of the thickness of the

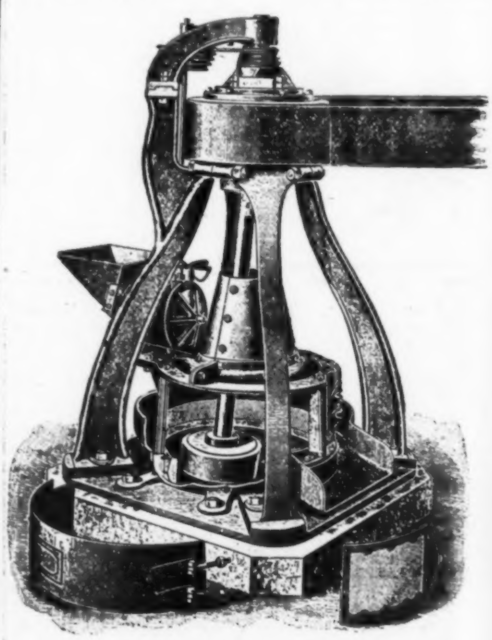


FIG. 44. THE GRIFFIN MILL.

* From Bulletin No. 6 of the California State Mining Bureau. J. J. Crawford, State Mineralogist.

die put in their stead, on which the rollers are revolved, when the remaining ones can be taken up. It is claimed for these mills that they wear smooth, and even while crushing hard quartz, discharge freely (on account of large screen area), avoid sliming and flouring of quicksilver, are good amalgamators, can be cleaned rapidly, are easily put in place, and require small power for amount of work done.

The Griffin mill belongs to that class of mills using a roll running against a ring or die; but instead of several rollers, as in the Huntington, this has one roller only, swinging from a longer shaft, hung from a point in the central axis of the mill, and rotated about its own axis by the power applied at the top. It is run at a speed of 190 to 200 revolutions per minute, crushing from 1½ to 2½ tons per hour, the power being applied to a horizontal pulley above, from which the shaft is suspended with a universal joint, and the roller is rigidly attached to the lower extremity of the shaft. The roller swings in a circular pan supplied with a ring or die, against which the roller works; and carries on the under side scrapers or plows to prevent the pulp from baking. A circular screen frame is fastened on the pan, to the top of which a conical shield is attached at the apex, through which the shaft works. The pulley revolves upon a tapered and adjustable bearing, supported by the frame composed of iron standards, two of which are extended above the pulley to carry the arms in which is secured the hollow journal pin. The shaft is suspended to a universal joint within the pulley. This joint is composed of the ball or sphere with trunnions attached thereto, which work in half boxes that slide up and down recesses in the pulley head casting. The lubricant is supplied, for all parts needing it, through the hollow pin. The roll revolves within the ring die in the same direction that the shaft is driven, but on coming in contact with the die, it travels around the die in the opposite direction from that in which the roll is revolving with the shaft. A pressure, by centrifugal force, of 6,000 lb. is brought to bear on the material being pulverized between the roll and die. The water is introduced with feed when running, and receives a whirling motion from the roll, which brings the pulp against the screens, 9 ft. in area. A circular trough on the outside of the pan conducts the pulp to one side, where it discharges over an apron.

TYPICAL CALIFORNIA GOLD MILLS.

As the details in milling practices of the several counties of the State vary greatly, the following typical mills have been selected to indicate the practice under varying conditions:

No. 1. Amador County.—The ore is a soft, easily crushed quartz, with about 1½ per cent. sulphurets,

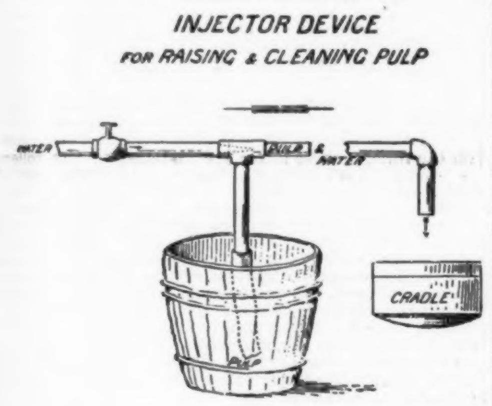


FIG. 45.

and is largely mixed with slaty material, which, to the extent of 25 per cent., is found mixed with the concentrates. The stamps weigh 750 lb. each, and drop 6 in. about ninety-five times per minute, discharging through a No. 8 slot screen, at the rate of 2½ tons per stamp in twenty-four hours. The stamps drop in the following order: 1, 2, 3, 5, 4; Nos. 1 and 2 having ½ in. more drop than the other stamps; in the adjoining battery the order is reversed. Iron shoes and dies are used. There is an inside plate used in the battery, which retains about 75 per cent. of the amalgam. The apron is 48 in. × 13 in., set on a grade of ¾ in. to the foot, and the double sluices below are 9 ft. long by 14 in. wide, with a grade of 1½ in. to the foot. From these sluices the pulp passes to vanners. To clean the sulphurets from the slaty admixture, a cradle, 12 ft. long, 20 in. wide, and 4 in. deep, has been placed in the mill, run by an eccentric. The dirty, slimy sulphurets are taken from the washing boxes beneath the vanner and placed in a half barrel standing on the floor of the mill, into which a hose is lowered, and the sulphurets are raised from the barrel to the cradle by creating a vacuum, through a small jet of water under pressure forming an ejector. The pulp in the cradle is stirred vigorously toward the head; the grade is from 7 in. to 8 in. in 12 ft. This washing in the cradle relieves the pulp of about 25 per cent. of waste material. Twelve tons can be washed in a day. The canvas plant below the vanner has some interesting features. The canvas strips are only 12 in. wide. The pulp as it leaves the vanner is carried to a mercury trap, consisting of a box of diminishing width, with three upright divisions, under and over which the pulp flows. From the mercury trap the pulp falls into a long box, about 1 ft. square at the ends, in the bottom of which are ten holes, whose size is regulated by experience. They must equalize the discharge with the inflow from the mercury trap. The pulp introduced into the long distributer box sizes itself to some extent by gravity; the finer material, being held in suspension longer, finds its way out at the end of the box, while the coarse quickly passes through the holes in the bottom, nearer the center of the box.

There are twelve strips of canvas, 100 ft. in length, each strip having a width of 12 in. and a grade of 4½ in. in 12 ft. The coarse material is all found on the six center sections, the two outside sections on each side carrying the finer material. An additional series of tables, with 20 in. wide sections and a grade of 9 in. in 12 ft., receives the pulp after passing over the first.

No. 2. Amador County.—The practice of this mill in handling their tailings may be taken as an example of the better methods now practiced in the State. This mill has 900 lb. stamps, dropping 85 times per minute, with a 6 in. drop and a 7 in. discharge, kept constant by the use of lower chock blocks. No. 30 brass wire screens, 4 ft. long and 4 in. wide, set vertical, are used, giving a duty per stamp of 2½ tons in twenty-four hours. The batteries are supplied with

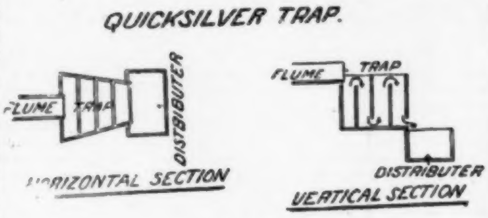


FIG. 46.

inside front plates. The apron plates are 46 in. × 30 in., set on a grade of 1¾ in. to the foot. These are followed by 18 ft. of sluice plates, 15 in. wide, the first 10 ft. of which are double. About 66 per cent. of the amalgam is recovered in the battery. The loss in quicksilver, which is introduced into the battery every half hour, amounts to about 1½ cents per ton. The total cost of milling at these works is given as 70 cents per ton. The mill is supplied with three vanners to each battery, with 4½ ft. belts. The pulp from the plate sluices passes directly to the spreaders of the vanners, a division into thirds being first effected. After leaving the belts, the pulp flows through sluices to a flume, where it is divided into two equal streams by the insertion of an adjustable division plate in the flume. The divided pulp passes to two steel screens with perforations of ⅛ in. and $\frac{1}{16}$ in. respectively, which form the bottoms of two 4 ft. boxes, 1 ft. wide, set on a reverse grade of 6 in. in 4 ft. These boxes prevent any foreign substance from passing through into

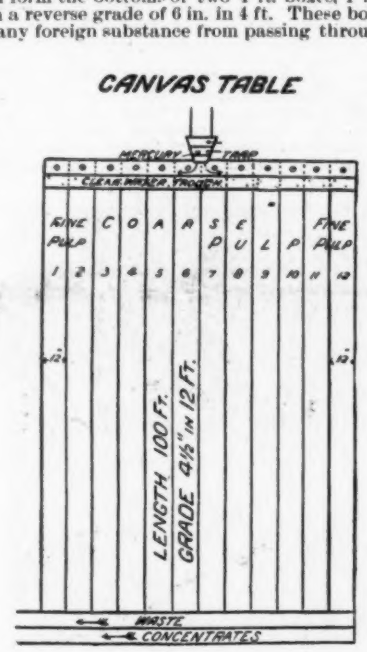


FIG. 47.

the sizing box below, and clogging the outflow pipes. After the passage of the screens the pulp falls into a separator, consisting of a wooden V-shaped trough, 6 ft. long, 15 in. wide on top and 2 in. at the bottom, with a flat, funnel-shaped discharge pipe of galvanized iron attached at one end, ending in a round 2 in. pipe. As more pulp enters the separator than can be discharged through the 2 in. pipe, it fills and flows over the end into a launder: the heavier and larger particles sinking down and passing through the pipe. The overflow passes on a spreader that delivers it to a canvas table, with ten sections; a second similar table, placed below, receives the waste from the first one. The tables are 12 ft. wide, 13 ft. long, and set on a grade of 1½ in. to the foot, and to secure a proper

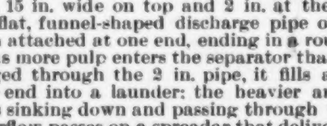


FIG. 48.

grade for the waste sluice, each section is set 4 in. below its predecessor. All the waste water passing from the tables is used a short distance off as power on an overshot wheel that runs a vanner, on which are worked the concentrates taken from the tables.

No. 3. Butte County.—The quartz carries considerable sulphurets. When hoisted from the mine it is dropped immediately over a grizzly, with the bars placed 1½ in. apart; the coarse rock crushed is loaded into cars, and trammed to the mill, distant about 150 yards, and dumped into bins which are calculated to carry 1,500 tons. From here chutes convey the ore to the Challenge self-feeders. These are operated from the center stamp in each battery. The stamps, which are supplied with steel shoes and dies, weigh 850 lb., drop 7 in., and about 100 times per minute; the discharge is 7 in.; the screen is No. 8 diagonal slot, 8 in. wide; each stamp crushes 2¼ tons per 24 hours. The screens, which last about four weeks, are used later in the chlorination works for the recovery of cement copper. From the mortar the pulp passes over a 14 in. mortar plate; thence to a 4 ft. apron and 12 ft. of sluice plates; aprons and plates are set to a grade of 3 in. to the foot. The pulp then passes over the vanners, two for each battery, after leaving which, it is conveyed to the canvas platform house. The canvas platform is 24 ft. wide and 60 ft. long, covered with x 2 0 0 canvas, and below it are 150 ft. of settling boxes. The plates are scraped every day, and dressed besides, when required.

No. 4. Calaveras County.—The rock consists of massive quartz, schistose and slaty diabase, and chloritic and talcose schist, with iron sulphurets; it is crushed in jawbreakers at the head of the shaft, after passing over grizzlies, and is dropped into bins, from which the ore is conveyed, in cars, to three other bins in the mill, one for each section of twenty stamps, having a capacity of 600 tons each. The bins discharge into Challenge self-feeders. The sixty stamps weigh 775 lb. each, and drop 105 times per minute, the drop being 6 in., and the discharge 10 in. from the new die. Only one chock block is used, causing the height of discharge to constantly increase. The duty of the stamps is 4 tons in twenty-four hours. Round punched tin screens, 10 in. × 14 in., are used. They are lightly burned before using. Three and a half of the screen sheets are tacked on the screen frame on three sides; the top side is secured by a long, narrow strip of wood screwed to the frame. The superficial area of the discharge is about 287 sq. in. The screen frame is braced by six cross ribs, to which the screens are tacked. A splashboard is suspended in front of the screen by eyebolts and hooks, with a strip of canvas tacked along the bottom, the full width of the screen. An iron apron or table is secured to the front of the mortar below the screen, the bottom of which falls 1 in. below the lip of the mortar, permitting the insertion of a rough inch board, 9 in. in width, in front of the mortar, flush with the upper edge of the lip of the mortar; on this the pulp falls from the screen, and is claimed to be superior to a plate in retaining the amalgam. Three inches below the board runs a trough, in which are two apertures one-third the distance from each end, which allows the pulp to fall on a short, 6 in. wide copper plate with a pitch toward the mortar, and from thence to the apron plate, 2 ft. wide and 24 ft. long,

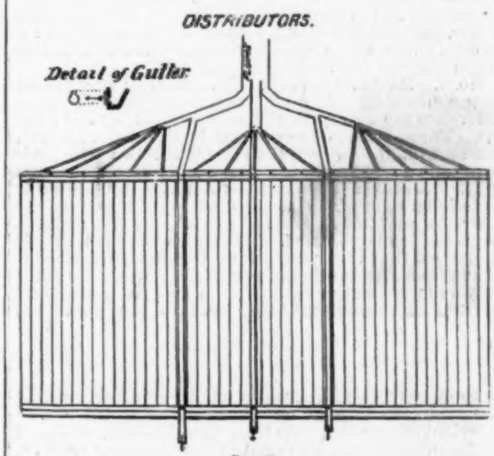


FIG. 49.

set to a grade of 2 in. to the foot. An inside-front plate is used in the mortar. From the apron plate the pulp passes to a sluice box and is conducted to the spreaders of the vanners, of which there are twenty-four. After leaving these, the pulp is led through a sluice box and flume one mile long to the canvas plant. The plates are dressed every morning; a battery is hung up, the water shut off, the splashboard removed and washed off, as also the screen and the entire front of the battery, to remove all sand; the plate is then vigorously scoured with a whisk broom to loosen the amalgam. A very dilute solution of cyanide of potassium is sometimes used during this operation, and the loosened amalgam brushed to the foot of the plate. The plate is then scraped upward with a piece of rubber 4 in. × 4 in. and ⅜ in. thick; a piece of rubber belting would answer the same purpose. The collected amalgam at the head of the plate is removed in a scoop and placed in a safe. The plate is then sprinkled lightly with quicksilver, which is spread evenly over the entire plate, the water turned on, and the stamps dropped. The operation for all the plates requires nearly three hours.

A clean-up of the mill is made monthly or semi-monthly, according to the condition of the battery amalgam, at which time all necessary repairs are made, and new shoes and dies are fixed, if required. Shortly before hanging up, the feed is shut off to permit the ore to be crushed down as low as possible. The water is then shut off from the battery, splashboard and screen removed, and all hosed off: the inside plate is removed, and the amalgam scraped off. The contents of the battery are now removed, and placed in the revolving clean-up barrel, the dies replaced, tappets set, screens replaced, and the mill started. The pulp that leaves the mill carries considerable auriferous pyritical slimes, as might be inferred from the high discharge used in the battery. This is conveyed through a sluice 12 in. × 8 in., to a canvas plant one mile distant. Just before entering the building set apart for the recovery of these slimes, the sluice is widened to 18 in., and divided into three sections by two narrow strips fastened to the bottom. These divisions fork off into separate sluices, which are again subdivided. Three of these subdivisions are carried directly through the

building, and there divided, and the other three are divided off in five separate sluices, one for each section of the canvas table. There are forty-five sections for each table—ninety in all. They are 42 ft. long, 22 in. wide, and set on a grade 1½ in. to the foot. No. 8 duck canvas is used, and when worn on one side it is turned; it lasts about one year. The last division of the pulp, outside the building, is into five boxes, 4 in. square, each of which terminates in a receiving box, reaching across three canvas sections, about 5½ ft. The five divisions supply one-third of the sluices on one side of the building; the pulp passing to the canvas through an auger hole in the side of the box. The flow is regulated by a slide suspended over the whole. Above the pulp distributing box is a clear water box, and at the lower end of the canvas tables are two sluices, side by side—one to receive the concentrates, the other for the reception and discharge of pulp. The current must be thinned and distributed so that no accumulations form.

No. 5. El Dorado County.—The quartz carries considerable slate mixed with it, and about 3 per cent. of iron sulphurets. The stamps weigh 950 lb. each, and drop 4 in. 104 times per minute, discharging through a No. 2 sheet tin, perforated screen with from 5 in. to 7 in. discharge, crushing 3 tons per stamp in twenty-four hours. The shoes and dies are both steel. The battery is supplied with an inside plate in front. The apron plates are 16 ft. long, set on a grade of 1¾ in. to the foot, and are followed by 6 ft. of sluice plates, 2 ft. wide, on the same grade. These plates are dressed every day, but only scraped once a month. (Note:—This is not advantageous, as the constant scouring action of the pulp undoubtedly detaches fine particles of amalgam.) The batteries yield 62 per cent. of the amalgam. Eight Woodbury concentrators receive the pulp. The quicksilver is introduced into the battery every half hour; the loss of quicksilver being estimated about one pound to every ten tons of ore.

No. 6. El Dorado County.—The quartz carries about 2 per cent. of sulphurets and contains slate mixed with it. The stamps weigh 750 lb. each and are fed by Challenge feeders; no rock breaker is used. The stamps make 96 drops per minute, varying from 4½ in. to 6 in., with 7 in. discharge. The mortars are wide, and have an 8 in. wide inside amalgamated plate; the screen is perforated tin, equal to No. 7. The apron is 54 in. by 42 in., with grade of 1¾ in. to the foot, followed by sluice plates 12 ft. long, which are double on one battery and divided into four divisions on the other; this latter arrangement gives better results. Below the sluice plates is a blanket sluice, 6 ft. long and 14 in. wide, the blanket being washed twice a shift. From these the pulp passes to the Frue vanners with 6 ft. belts; the same wheel runs both stamps and vanners. The plates are dressed twice in twenty-four hours, but are not scraped until the clean-up, once a month. One and three-quarters tons are crushed to the stamp per twenty-four hours.

No. 7. Mariposa County.—This mill is working on ores containing gold in a very finely divided state. There are ten stamps of 900 lb. each, fed by self feeders. These stamps drop about 96 times per minute, with a 7 in. discharge while the die is new; when it is worn down one-half, a smaller chock block is placed under the screen. The pulp is retained in the mortar for a long time. The stamps are only raised to the level of the water as it stands in the mortar; and a front inside plate is used. The screen is a 60 mesh. It is claimed that 70 per cent. of all the amalgam saved is taken from the inside battery plate. There are three apron plates to each battery; the first is immediately in front of the splashboard, next to the lip of the mortar, 12 in deep and the width of the mortar. This is followed by a 2 in. drop onto a second plate 3 ft. deep, across the width of the mortar, succeeded by a 1 in. drop to a 4 ft. apron plate. From this plate the pulp passes immediately through distributing pipes to the vanners, of which are three. Two of these are 4 ft. wide, taking the pulp from one battery, while a 6 ft. belt vanner takes the pulp from the other battery. The narrow belt vanner gives the best satisfaction.

No. 8. Nevada County.—The ore is delivered by car at the top of the mill into grizzlies, the bars of which are 2¼ in. apart, and which deliver the coarse stuff to a crusher of the Blake type, through a bin with chute immediately over the crusher, keeping the same constantly supplied without the aid of a shovel. From the rock breaker the ore is delivered into bins with chutes connecting with the Challenge self-feeders. The feed is operated from the center stamp. The stamps drop 7 in. and 86 times per minute, with a 4 in. discharge. Steel shoes on iron dies are used. The screens are English sheet tin, perforated, No. 10, five pieces making a complete screen, costing 50 cents, and lasting one month. The steel shoes on iron dies have records of over 300 tons to the stamp, the daily average being from 1¾ to 2 tons per stamp. The plates are divided into an upper apron, 18 in. wide, followed by a 4 ft. apron. Between the two, catching the pulp from No. 1, is a box 3 in. wide, with a perforated screen bottom, somewhat coarser than the battery screen. This acts as a distributer on No. 2 apron, retaining any coarse pieces. For the forty stamps and accompanying concentrators, 15 miner's inches of water are used, all applied on the inside of the battery. The aprons have a ⅝ in. grade to the foot. Below the apron are 12 ft. of sluice plates, part of them 30 in. wide, while the others have the same width as the apron above. These plates are cleaned up every morning with pieces of rubber belting: it takes about 15 minutes to clean one set. From the sluice plates the pulp passes over a 12 ft. shaking-table covered with silver plates; these plates receive their motion from an eccentric placed underneath. Passing the table, the pulp enters a box, from which it is conveyed through pipes to the vanners on a lower floor, two for each battery.

No. 9. Nevada County.—The stamps weigh 730 lb. each, drop 6 in., 95 times per minute, with from 4 in. to 6 in. discharge, and crush from 1¾ to 2 tons per day, using steel shoes and dies. There is a 5 in. wide silvered plate in the front of the battery. A No. 9, perforated, sheet tin screen is used; it is not burnt before putting on, and is turned when the lower edge is worn, lasting on an average 30 days. In front of the screen is a splashboard, provided with an 8 in. plate next to the screen. The upper apron plate is 18 in. deep, set on a grade of ¾ in. to the foot, with 12 ft. of apron plates below, divided into four plates of 3 ft. each, set on a grade of 1 in. to the foot. From these the pulp drops into a box running across the end of the plate, from whence it passes to the vanner. The plates are scraped every twenty-four hours, with the exception of the upper 4 in. next the mortar, and are dressed twice a day, using dilute cyanide of potassium. Both rubbers and chisels are used in scraping the plates. In cleaning up the batteries, which occurs once per month, the headings are put into a revolving barrel with pieces of iron and quicksilver, and after running several hours, the contents are removed in buckets, the sand "boiled out" with the hose, the dross skimmed off, and the quicksilver strained. About 75 per cent. of the amalgam is saved in the battery. The tailings assay from 25 cents to $1.50 per ton.

No. 10. Nevada County.—The stamps weigh 800 lb. each, and are given a 6 in. drop, 100 times per minute, with a discharge varying from 2 in. to 4 in.; there are no plates in the battery. The ore passes over grizzlies, with bars 1½ in. apart, to a No. 2 Blake crusher; thence to the ore bin that supplies the Challenge feeders, which are operated from the center stamp. Steel shoes and iron dies are used—the shoes lasting, on an average, 155 days; the iron dies, 70 days. No. 6 Russian iron slot screens are used. The outside mortar plate is 14 in. wide, with ⅛ in. pitch to the foot, and retains 75 per cent. of the plate amalgam. The apron below is 4 ft. by 4 ft., with a grade of ¾ in. to the foot. Beyond this are 12 ft. of double sluice plates 12 in. wide, and with ¾ in. grade to the foot. Three sand boxes separate the different apron plates. From the sluice plates the pulp passes directly to the concentrators. The duty of the stamps is two tons per day. The tailings assay $1.80 to $2 per ton. From 10 to 12 lb. of quicksilver per month is used for the 40 stamps. The plates are scraped every day, and the batteries cleaned once a month, the headings being worked in a Knox pan. A weak solution of cyanide of potassium is used in dressing the plates.

(To be continued.)

[Continued from Supplement, No. 1045, page 16698.]

COMMERCIAL FIBERS.*

By D. Morris, C.M.G., M.A., D.Sc., F.L.S., Assistant Director of the Royal Gardens, Kew.

Lecture III.—(Continued.)

V. Paper Making Fibers.

Paper making depends entirely on vegetable fibers for the supply of cellulose, which is the essential element in all papers. Without cellulose there could be no paper. Paper is the result of felting together in the wet state of fiber cells obtained from the bast of exogens and the fibro-vascular bundles of endogens, already described. In treating material for paper making, the object of the paper maker is to get rid of a portion or of all the extraneous substances other than pure fiber; the solvent for such extraneous matters may be cold or hot water, with alkaloids or acids, with or without pressure; and according to the degree to which the ultimate fiber has been purified of extraneous matters, the better it bleaches, and the better the color and quality of the paper produced from it.

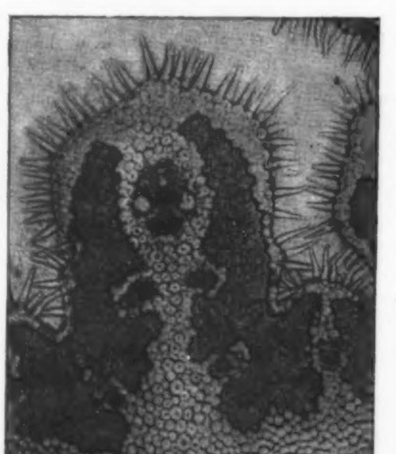


Fig. 19.—ESPARTO (STIPA TENACISSIMA).

Transverse section of a portion of a leaf of esparto, showing one of the projecting ribs on the inner side with a bay on either side, all armed with silicious hairs. The darker areas are the chlorophyl-bearing cells. The whole of the lighter portions occupying the lower part of the field, and extending upward between the chlorophyl-bearing cells, are the thick walled fiber cells. × 150.

The quantity of paper produced annually in Europe is estimated at 1,000,000 tons, of the value of £30,000,000; of this sum one-half is the cost of the raw material.

The vegetable substances from which paper can be made are very numerous. The difficulty is to find a substance at once cheap enough to be used profitably and abundant enough to secure a continuous supply. About 20 years ago, paper materials were becoming so scarce that the whole world was searched for them. Bamboos, straw, wild grasses, banana stems, the rejections of spinning and weaving industries, torn and waste, jute butts, rags and cuttings of all kinds were utilized. No woolen goods nor any animal fibers, as they contain no cellulose in an appreciable quantity, could be used for paper making. As showing the diversity of the material from which paper could be made, "a paper maker at the Paris Exhibition showed more than 60 webs or rolls of paper, each made from a different vegetable fiber." At the present time only two have come into use to a large extent; these are esparto and wood pulp. Cotton and linen rags are regarded as very important, if not the most important, materials for paper making purposes. They can, however, only be used profitably in the best papers. Cheap papers are largely made of mechanical wood pulp, mixed with kaolin or china clay. Such papers have no durability, and are quite unsuitable for bookwork.

* Lectures before the Society of Arts, London, March, 1895.—From the Journal of the Society.

ESPARTO.*

The esparto is a tufted grass (Stipa tenacissima) allied to the ornamental feather grass. The leaf sheaths are hairy internally, and hence esparto can be easily distinguished from a somewhat similar, but inferior grass (Albardin), formerly introduced instead of the genuine article. Esparto grows in dense clumps, with the culms from 1½ to 2½ feet high. It thrives extremely well in sandy and rocky soils, at moderate elevations, near the sea coast. It is abundant in North Africa and in some localities of Southern Spain. The plants are growing wild over extensive tracts of country, and the only expense is, practically, the cost of collecting and shipment.

From very ancient times esparto was used for making carpets, ropes, baskets, nets, and as a substitute for horse hair. These were prepared from the long leaves grown inland, now not considered so good for paper making as those growing near the sea coast.

The harvest of esparto commences in August and lasts up to October. About 10 tons of dry esparto may exceptionally be obtained from one acre. The four sorts of commercial esparto are named after the country of origin. The Spanish is regarded as the best, then come the Algerian and Tunisian, and lastly the Tripoli esparto. A small quantity occasionally comes from Morocco. Spain for a long time supplied the whole of the esparto of commerce, but latterly its exports are small compared with those of North Africa. The area under wild esparto in Algiers is estimated at 2,500,000 acres, but a good deal is beyond reach or facilities for transport to the coast.

The extensive use of esparto for paper making is greatly due to the exertions of the late Mr. T. Routledge. He commenced with a few tons at the Eynsham mills, about 40 years ago. It is of interest to note that the paper for the number of the Journal of the Society of Arts for November 28, 1856, was made of it. The use of esparto extended very gradually. The annual value has, however, of late reached nearly a million sterling. The United Kingdom has, hitherto, monopolized the supply. The imports for the last thirty years have been as follows:

1861	891 tons.
1870	89,156 "
1880	191,229 "
1890	217,078 "

The highest imports were in 1888, when they reached 248,836 tons. Since 1890, the imports have somewhat declined. In the year 1894 they were only 184,910 tons.

There is apparently a disposition, except in Scotland, to give up the use of esparto in favor of the cheaper and inferior wood pulps. The fibers in esparto are easily dissolved and bleached. An authority on paper making writes: "They felt readily, and yield an excellent pulp, which is employed alone or mixed with rags, wood pulp, or straw. They furnish a paper pliant, resistant, transparent, and of great purity; thicker than other papers of the same weight, and forming a good printing and writing substance." The falling away in the use of esparto for paper making, and the substitution of cheap paper pulps, must therefore be regarded as likely to lower the general quality of English-made paper.

The following table will show the comparative value of esparto in 1878 and 1895 respectively. The great falling off in prices of late years is due, as suggested, to the competition of wood pulp. The figures are compiled from the circulars issued by Messrs. Ide and Christie, 72 Mark Lane, E. C.:

Quality.	Price per Ton.				
	1878.		1895.		
	£	s.	£	s.	d.
Spanish, fine to best, average ..	10	5	5	2	6
" fair to good, "	10	0	4	12	6
Algerian—					
Oran, first quality, "	7	10	3	12	6
" fair to good, "	7	0	3	2	6
Tripoli, hand picked, " ...	6	10	3	9	6
" fair average, " ...	6	0	3	5	0

BHABUR GRASS.

Bhabur grass (Ischæmum angustifolium) might be regarded as the esparto of India. It closely approaches the latter in habit and in the technical qualities necessary for paper manufacture. The late Mr. Routledge tried Bhabur in 1878. His opinion was favorable: "A small quantity of bleach," he said, "brings it up to a good color. The ultimate fiber is very fine and delicate; rather more so than esparto, and about the same strength; the yield, however, is 42 per cent., somewhat less. . . . I may venture to say that it will make a quality of paper equal to esparto." Since 1878 Bhabur grass has become very largely used in India. At the present time it affords—as stated by Dr. King, F.R.S., who first called attention to it—"the chief raw material for paper making in the neighborhood of Calcutta and other parts of India." The grass is very common in the Siwalik range and in the Bhabur forests of the Gharwal and Kumaon Himalaya. It is found in the forests of Chota Nagpur. The prospect of utilizing the grass would be, no doubt, improved if it were cultivated. This is readily practicable. It yields at present two crops in the year, one in September, and the other in October

* The Spanish form of sparton, cordage.

or early in November. It might yield a third if irrigated. (Kew Bulletin, 1888, pp. 157–160, with plate.)

STRAW.

Although, properly speaking, it is the straw of esparto that is used for paper making, it is so superior for this purpose to ordinary straw that it deserves to stand alone. The straw of numerous cereal grasses is employed where obtainable; rice straw is used in Asia; wheat, oat, and other kinds in Europe. "For low papers straw commands a market, but as a mixer it is inferior to esparto, the internodes or knots being exceedingly troublesome, and difficult to get rid of."

WOOD PULP.

The deficiency in paper materials led to the use of pulp made from the wood of certain trees. The woody stems of trees are composed of (1) vessels or long continuous tubes with peculiar markings, due to the walls being unequally thickened; (2) fibrous cells composed of long, thick walled cells with sharply pointed ends, the wall is thickened nearly all over, but there are a few narrow pits where the wall is left thin; (3) of woody parenchyma having cells with square ends with rather thick walls and small pits. The woody character of the fibrous cells is due to the presence of lignine. This renders them much harder and stiffer than those of pure cellulose, as found in cotton. In the manufacture of wood pulp the object is to break up and reduce the wood cells so as to form a suitable material for paper making. Mechanical wood pulp is prepared by merely grinding the wood of certain trees, such as poplar, aspen, spruce, and fir, into a fine creamy condition, and afterward washing out some of the impurities with water. There is still left a large amount of lignine and other substances which are injurious to the quality of the paper. Mechanical wood pulp is often of sufficient whiteness to be used for what are called white papers, but such papers become discolored with age, and perish on exposure to a damp atmosphere.

Wurster has devised a test based on the depth of color given by these papers, so that he can arrive at a quantitative estimation of the proportion of mechanical wood pulp contained in them. Chemical wood pulp is produced by treating the ground wood with chemicals to remove the resin, and all ligneous and mineral deposits, leaving only the fibrous cells composed of almost pure cellulose. The various sorts of chemical wood pulp (often called wood cellulose) are named according to the chemical agents employed in their manufacture. These may be sulphite pulp, soda pulp, or sulphate pulp, according as they are prepared either with sulphite of lime, caustic soda, or sulphate of soda. The common spruce and the silver fir are the chief species that supply the chemical wood pulp of Europe, while the white spruce, black spruce, Canadian hemlock, white American pine and silver fir, furnish the chemical wood pulp of the United States and Canada.

The rapid progress made in the use of wood pulp for paper making is one of the most remarkable among modern enterprises. In the United States, in 1886, only about 97,000 tons were produced. During 1894 the quantity was estimated to exceed a million tons of the value of £5,000,000. Mr. S. P. Eastick states that the pulp necessary for the daily editions of one New York paper absorbs the timber from about seven acres of an average forest. Although at first only intended for paper making, wood pulp is capable of being so hardened that it can be successfully employed for the manufacture of furniture, carriages, floor covering, kitchen utensils, etc. It can also be dyed any color and rendered fire and water proof.

The most suitable wood for the manufacture of chemical wood pulp is derived from the Coniferæ. Hence the pine forests of the United States and Canada, as well as those of Europe, have considerably increased in value. In many cases the small logs and waste of saw mills can be utilized for wood pulp. Sawdust has been found unsuitable, owing to the difficulty of treating it effectually. Canada is very advantageously placed for a wood pulp industry. It possesses, as one authority states, "vast forests of suitable wood, whose quality cannot be surpassed; it has magnificent rivers for transporting logs and produce, and enjoys the advantage of numerous seaports and low ocean freights to Europe."

Norway and Sweden take the lead in the wood pulp industry of the old world. The estimated exports of mechanical wood pulp for 1894 were about 240,000 tons, of the value of £500,000. This is nearly double what it was six years ago. There were 61 machine wood pulp factories, of which three were attached to cardboard factories and ten to paper factories. A large quantity of the Norwegian wood pulp is shipped to the United Kingdom, but France and Germany also take increasing quantities. In the preparation of chemical wood pulp or cellulose there were ten turning out sulphite pulp and four turning out soda pulp. The exportations in 1894 were about 34,000 tons of dry and 10,000 tons of moist pulp, against 32,000 tons of dry and 13,000 tons of moist in 1893. The annual value of the chemical wood pulp industry is about £320,000. A large proportion of this pulp is shipped to the United States.

NEPAL PAPER PLANTS.

Although, at present, there is little prospect of any paper material competing successfully with wood pulp, it is desirable to mention a few fibers that possess exceptional merit. Of these, the most prominent in India is the Nepal paper plant, Daphne cannabina (also known as D. papyrifera). This is a shrub or small tree found on the Himalaya between altitudes of 3,000 and 10,000 feet, on the Khasia and Naga hills, and it is one of the most abundant bushes on the hills between Manipur and Burma. It is said that the well known Nepal paper is made from the bast fiber of this and other species of Daphne, and of the allied Edgeworthia Gardneri. Dr. Royle states that, at the exhibition of 1851, a sample of Nepal paper was shown of such size as to occasion universal surprise. He states: "This paper is remarkable for its toughness as well as its smoothness." An engraver, who tried some of this paper, stated that "it afforded finer impressions than any English made paper, and nearly as good as the fine Chinese paper which is employed for what are called India paper proofs." As Daphne paper can be purchased throughout India, it is evident that the manufacture of it by the hill tribes, who alone produce it in quantity, must be very extensive. Dr. Watts remarks: "Daphne paper will endure for many years under a treatment that, in a few weeks, days, or

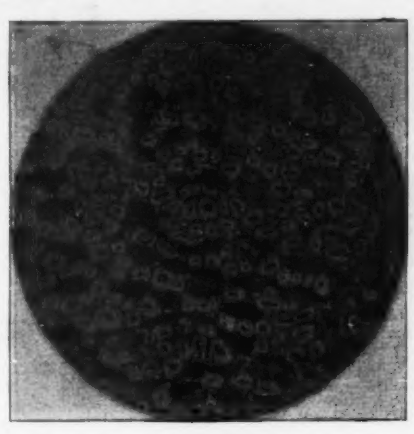


FIG. 20.—NEPAL PAPER PLANT (DAPHNE CANNABINA).

Transverse section through the bast area, showing the characteristic disposition of the fiber bundles. The cells vary in diameter, in thickness of the wall, and size of cavity. × 150.

even hours, would render the modern papers produced in England perfectly worthless."

PAPER MULBERRY.

The paper mulberry (Broussonetia papyrifera) is widely distributed throughout Eastern Asia and Polynesia. It is extensively used for making paper and also the Tapa cloth of the South Sea Islands. The Japanese propagate the plant very much as willows are grown in England. They use only the young shoots for the manufacture of paper. Mr. Routledge stated that the bast of the paper mulberry was nearly, if not quite, the best fiber he had ever seen. It required very little chemicals and gave an excellent yield—62·5 per cent. in the gray and 58 per cent. bleached. The Japanese use paper made from this plant for a variety of purposes, such as umbrellas, lanterns, and books of all kinds. In the Kew Museum is a specimen of Tapa cloth, originally part of a roll that measured two miles in length by 120 feet wide. This belonged to the King of Tongataboo, one of the Friendly Islands. A paper very similar to that prepared from the paper mulberry is obtained in Siam from Streblus asper. This is a weedy looking tree abundantly distributed throughout India, Ceylon, and tropical Asia. White Streblus paper is used for legal documents and government correspondence, while a black paper written upon with talc is used for rough draughts and for taking evidence in native law courts (Kew Bulletin, 1888, pp. 81–84).

VI. CELLULOSE INDUSTRIES.

In concluding these lectures, it is desirable to say a few words on the industrial application of cellulose other than for fiber purposes. We started by regarding cellulose as the essential element in all fibers. We have seen, in the course of our inquiry, that the larger the percentage of cellulose, the better the fiber. It is not too much to say, in regard to the manifold uses to which cellulose can be put, that it is one of the most important bodies in the whole realm of nature. The most abundant and accessible form of pure cellulose is the floss of cotton and the silky seed hairs of many plants described in the first lecture. It is also found almost pure in well bleached fabrics, made of linen, hemp, and in the best, unsized, white paper. The use of cellulose, now to be dealt with, is based on the facility with which it can be dissolved or gelatinized in the presence of certain metallic compounds, or by means of nitric and sulphuric acids. By means of the latter it yields the cellulose nitrates which find a number of highly important uses in explosives, such as guncotton, and when associated with nitro-glycerine in the newer explosives known as blasting gelatine, ballastite, and cordite.

Schultze powder is prepared by macerating soft timber until only pure cellulose remains. This is nitrated with acids, and forms a powerful powder that is almost smokeless. Other nitrates of cellulose are worked up with camphor and similar substances into celluloid and xylonite, forming plastic masses which can be cut and moulded into articles of the most varied form and use. Besides these there is collodion (pyroxylin), a nitrate of cellulose dissolved in ether alcohol, forming transparent solutions, which, on evaporation, leave a film of considerable elasticity and tenacity. There are surgical or medicated collodions and photographic collodions. The cupra-ammonium solutions of cellulose are utilized in the production of what are known as "Wilesden" goods. "Vegetable textile fabrics when passed through a bath of the cupra-ammonium hydroxide are 'surfaced' by a film of gelatinized cellulose, which retains the copper oxide in such a way that it dries of a bright 'malachite' green color. By this treatment the fibers are further compacted together, and the fiber acquires a water resistant character. The presence of the copper oxide is also a preservative against the attacks of mildew, insects, etc. If the fabrics are rolled or pressed when in the gelatinized condition, they become firmly welded together on drying and a variety of compound textures are produced in this way." (Cross and Bevan, Cellulose, p. 13.)

Another application of soluble cellulose is the product known as artificial silk. This is prepared by means of an apparatus which allows the soluble cellulose to be drawn off from the end of a glass tube on to a light wheel revolving at a definite rate. By this means the thread is kept continuously at a uniform diameter. Several threads being twisted together in the usual way of "silk throwing," the artificial textile thread is produced. "Artificial silk has been found to have a tensile strength equal to 70 per cent. of that of the natural product of the same degree of fineness." It is capable of being largely used industrially.

Viscose is the commercial name given to an acetate solution of cellulose likely to prove of great value. A series of preparations of viscose shown before the Society of Arts indicated varied uses for this substance. In the dry condition it is of a horny character, extremely hard, and very durable. In thin sheets it can be used for bookbinding and resembles the finest parchment. In solution it can be used to size paper and give a fine durable coating to jute and hemp goods, preserving them from the deteriorating influences of a damp atmosphere. Viscose also gives a good surface appearance to cotton goods and at the same time adds greatly to their strength.

ON A METHOD OF PHOTOGRAPHY IN NATURAL COLORS.*

IN 1861 Clerk Maxwell described a method of color photography, based upon his experiments on the theory of color vision, and made the following experiment:

Three photographs of a colored object were taken through three several colored solutions giving images which separately represented the object as it would be seen by each of the three sets of color nerves postulated by Young. When these were superposed the original colors of the object were reproduced, save for the defect that the red and green components suffered from the insensitiveness of the photographic plate of Maxwell's time to the longer wave lengths. Maxwell added the remark that when the photographic plate was improved as regards sensitiveness to the less refrangible rays, the representation of color would be improved.†

Since Maxwell's day the color blindness of the plate has been almost completely remedied, thanks to the discovery of Vogel, and it is now possible, proceeding on the lines laid down by Maxwell, to produce by triple projection upon the screen a picture which may be illusively like nature. For the application of modern resources and the suggestion of photographing to the color vision curves by special color screens, we have to thank Mr. Ives.

Composite color photography deals with the subjective reproduction of all visible wave lengths in two stages; a photographic analysis and an optical synthesis. In the first operation the several wave lengths are caused to produce three separate photographic images according to their physiological activity in exciting the supposed fundamental red, green and violet sensations. That is, if the image bears, for example, a yellow color (suppose such a yellow as the spectral yellow near the D line), one of the plates must record an image of the object having a density of silver deposit corresponding to the degree in which this wave length can excite the red seeing nerve, and a second must acquire a density corresponding to the degree in which this same wave length can excite the green seeing nerve.

The third plate records no impression, for the wave lengths near D excite no violet sensation; but this yellow sensation is the resultant of two physiological effects only, a red and a green sensation in certain proportions obtained by color measurements effected upon normal color sight. We have now obtained three negatives possessing densities of silver deposit corresponding to the degrees in which the three several fundamental color sensations are stimulated. These degrees of density will be interpreted as degrees of transparency in the positives.

The first positive, if backed with a red glass, will transmit a quantity of red light corresponding to the intensity of the physiological excitation of redness in the "red" nerves; the second, backed with green, similarly represents the stimulation of the "green" nerves by the yellow color of the object; the third positive is backed with blue violet glass, but is quite opaque, and no violet light is transmitted through it.

The projection now of all three images superposed upon the screen forms the second stage of the procedure; the optical synthesis of the original colors. The eye regarding the superposed image receives, in fact, the same amounts of red and green sensation, and experiences the same absence of violet sensation which would have attended the formation of the image of the original object upon the retina.

This process, if accurate reproduction of color is sought, necessitates the use of two distinct sets of color selective screens; for the analyzing screens will by no means possess the tints ultimately required in the optical synthesis. This is evident since the measurements on color vision reveal that the wave lengths

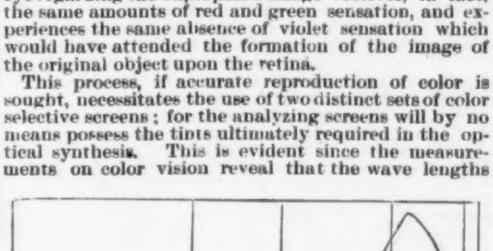


FIG. 1.

near D are more strongly stimulative of red sensation than are the purely red exciting wave lengths near C, and the wave lengths again diminish in their power of producing stimulation of the "red" nerves on the more refrangible side of D. Hence, in order to photograph the wave lengths of the spectrum, we require to produce a greater photographic effect by the D wave lengths than by the C wave lengths, and a photo-

* Abstract of a paper read before the Royal Dublin Society, by Dr. J. Joly, F.R.S.

† "On the Theory of Three Primary Colors." "Collected Papers," p. 449.

graphic effect diminishing above D in the same degree as the power of the waves to excite the fundamental red sensation diminishes.

To effect this analysis of the light a screen transmitting as predominant wave length a wave length near D must be used for obtaining the image which is to represent the appreciation of light peculiar to the "red" nerves. Such a screen has a yellow orange color, which is not the sensation excited in or transmitted by the "red" nerves. In the optical synthesis this must afterward be represented by a C red color. The same remarks apply to the other screens.

Maxwell's curves (Fig. 1) are not color sensation curves (Abney: "Color Vision," Tyndall Lectures, 1895), and it is misleading to speak of the foregoing method as effected on color sensation curves. Maxwell's curves represent, in fact, the subjective synthesis of the spectrum out of three chosen wave lengths—a red, a green and a blue violet. The question as to how far one or all these chosen wave lengths may excite more than the one set of nerves remains over, and indeed can only be gone into by examination of abnormal color vision. In Kœnig's curves of color vision, color sensations are plotted. These are shown in the named curves of Fig. 2.

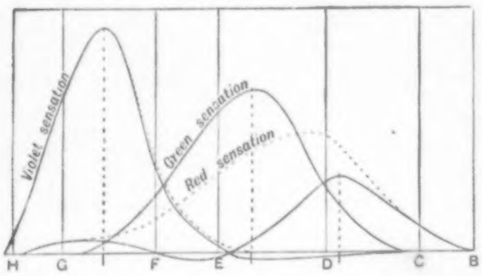


FIG. 2.

If, from the knowledge afforded by Kœnig's curves of the compound nature of the green sensation, Maxwell's curves be examined with reference to their suitability to serve the purposes of the photographic method, it will be found that, assuming Maxwell's E green to excite the proportionate amounts of red and violet sensation revealed by Kœnig's curves, a correct synthesis of the F green by Maxwell's curves is impossible. Although such a comparison is not strictly allowable, owing to the red and violet curves of Maxwell being based on different wave lengths to those used by Kœnig, the fact of grave inaccuracy is certain. This fact will appear if the spectrum is photographed according to Maxwell's curves. The blue-green will then be found to be produced too yellow in tone.

In order to apply the color sensation curves of Kœnig to the photographic method, we have to find by trial examinations of his curves the green most suitable for backing the "green" positive; for we see that the several green wave lengths excite very different amounts of red and violet sensation. We find as suitable a wave length a little to left side of the E line, about 550 $\mu\mu$. If we take this color to back the green positive, we must, in order to find the correct red and violet curves which are to control the densities of the red and violet images, replot the red and violet curves with allowance for the proportionate amounts of red and violet which will be carried to all those points where in the image of the spectrum the green curve operates. The red and violet curves must be lowered by amounts obtained by ascertaining from the height of the green curve at any point the amount of red and violet sensations excited by the amount of our selected green present at that point.

The final curves are shown in the slightly altered violet sensation curve, the original green sensation curve, and the consideraly lowered red mixture curve (as it may be called); the full line in all cases representing the applicable curves. It is seen that the amount of negative color (which cannot be realized) is small. Although it is possible that the compound nature of our green sensations will deny absolute accuracy to this method of color photography, still my own results on the curves just described, and the results of Ives and others on modified Maxwell curves, appear to show that a degree of accuracy baffling the criticism of the ordinary untrained eye may be attained and that in the reproduction of the most complex tints.

The symmetry of the derived curves renders their application easy. The transmission of light through a pigment is not limited generally to a small group of predominant wave lengths, but falls off uniformly at either side in the directions of longer and shorter waves. If we choose the pigments used on the analyzing screens so that their predominant transmissions are at three points in the spectrum indicated by the axis of symmetry of the three curves, these being nearly symmetrical, very accurate results are obtained.

The positions of these axes of symmetry are shown by the vertical dotted lines. Accordingly, I make the color of the red taking screen that of the spectrum at a point displaced to the red side of D by about one-sixth the interval D to C; for the green and violet taking screens the correct tints are found in the same manner by scaling from the figure. Good results are thus obtained, but I do not assert that these details of procedure are final.

Any method of photography in natural colors must possess the characteristics not only of accuracy of color rendering, but also of convenience of application and permanency of color, if it is to possess value as a scientific method. For use under the various circumstances of travel the naturalist requires a method no more cumbersome than the present dry plate. In the method of composite color photography, as described, the ordinary camera will not serve. The cumbersome necessity of obtaining three images remains, and subsequently no concrete image in natural colors is actually obtained. One can only be realized by triple projection upon a screen, or by using some optical contrivance which, by the aid of reflectors, enables all three images to be simultaneously projected upon the retina.

I now proceed to describe a mode of applying the foregoing principles which is free of the objection of cumbersomeness, and which enables us to realize a concrete image in transparent colors. A plate is finally produced which may be held in the hand, regarded against the light, and which bears an image of the object in natural colors, or such as are so nearly accurate as to seem so to the eye. In this new method there is but the one image photographed. The ordinary camera, lens, and backs, etc., are used without modification. The first class isochromatic plates in the market which are sensitized down to the C red will give very good resuts.

In the new method the idea is to carry the application of physiological principles still further, and divide up the plate like a hypothetical subdivision of the retina, so that all over the plate there should be minute regions uniformly distributed wherein the sensitive silver salt is excited to become reduced to the "photogenic" material in the same degree in which the sensations of redness, greenness, violetness, would have been actually excited in the several nerves of the retina had the image been formed upon it. Development builds upon this photogenic material the denser silver deposit, and ultimately in the positive the amounts of the sensations are registered in the degrees of transparency of the successive regions. The lined screen which can bring about this I can show you in the microscope. It consists of closely ruled adjacent lines in orange, green and violet tints. This screen, applied closely to the sensitive surface, analyzes the image in the camera. The screens I have used hitherto are coarse, about 200 lines to the inch, and even with this coarseness, will show plainly, I regret to say, the imperfections of the only apparatus at my command in preparing these screens. I may observe, in passing, that the colors are ruled on in pigments made up as inks in gelatine and gum arabic or dextrine, and upon plates coated with a preliminary layer of gelatine. Such lines may be put on so close as 800 or 1000 to the inch. With between 300 and 400 to the inch, however, the eye is no longer annoyed by the structure of the plates. The lines may also be ruled on celluloid or on translucent paper.

The appearance of both negative and positive obtained is interesting. One would hardly at first sight distinguish between them and the ordinary images. But a lens readily shows the difference. Recalling now that the lines upon the positive register in their degrees of transparency the degrees in which the three color sensations would have been excited, it becomes apparent that to complete the physiological parallel we must convert these degrees of transparency to quantities of the red, blue and violet color sensations. This is done by a second screen, which carries red, green and violet lines to the same gage as the taking screen. We apply this to the positive, and as we move it over the image, waves of every tint of color appear till that position is reached where the red lines fall over the lined areas recording red sensation, and so for the others. The picture now suddenly appears in vivid color and with all the realism and relief conferred by color perspective.

A picture of wallflowers taken through a dichromatic screen, the red and green sensations only being photographed, is of interest as realizing the appearance of the object to a violet blind eye. The rich reds and browns appear unaffected; the greens are, however, somewhat unnatural. A photograph of the spectrum shows the range of color from the C red to the H lines. The blue green is, however, defective. It was taken according to Maxwell's curves. Photographs of burnished metallic objects, as a brightly lacquered microscope, reproduce the metallic luster; and one of a uranium glass bowl reproduces the characteristic dichroism and fluorescent appearance of the glass when seen by daylight. That every shade of color can be reproduced, however complex, is shown by two portraits, one from life and one a copy of a water color drawing boasting very æsthetic shades of brown and olive. A great variety of bright sunlit colors appear in a view of the Trinity College athletic sports, wherein the scarlet uniforms of the military band, the green of the grass, and the blue sky, recall the vivid appearance of the image on the ground glass screen of the camera. The color perspective in such pictures adds greatly to the reality and relief. The faithful reproduction of texture, as in the case of some pansies where the velvety browns and purples of the originals reappear, or as in the case of the wallflowers, reminds us how much is inferred from the most subtile differences of light and shade in the colors of objects, in association with previous experience derived through other senses. The picture is always an optical illusion; and this additional illusiveness conferred on the photograph by the method invented by Maxwell on the basis of the three color theory of vision is surely a strong confirmation of that theory.

These results are attained by no new photographic operations. It is necessary to use good orthochromatic plates sensitized into the red, and also to have affixed in the lens an orthochromatic screen cutting off the ultra violet light in the usual manner. The exposure is somewhat longer than the ordinary exposure, for we can of course only use visible light, and of this a part is stopped by the taking screen. The ordinary backs may be used. The displacement of the sensitive film from accurate register with the ground glass camera screen owing to the presence of the taking screen in front of it, may be corrected (if thought necessary) by simply reversing the surface of the ground glass camera screen, turning the muffled side outward. This secures that the image will be accurately focused in the plane of the sensitive surface. Negatives and positives may be used as ordinary negatives or positives till it is desired to recall the original colors. Thus, for those who wander with the camera, the possession of but the one seeing screen to test results is sufficient, and of course the one taking screen suffices to take an indefinite number of plates.

These considerations lead us naturally to observe that the registration of color being really carried in the silver image, which with very little care in manipulation may be made permanent, secures that the colors are permanent. A faded screen may at any time be made good by a fresh screen; the colors in all cases being spectroscopically chosen, we are assured of the reproduction of the original color. In this aspect the necessity of the detached color screen is no disadvantage, but rather a necessary safeguard against the inevitable fading attending most pigment colors.—Nature.

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